UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1931

PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 10 cents

OFFICE OF EXPERIMENT STATIONS

JAMES T. JARDINE, Chief

RELATIONS WITH THE STATE EXPERIMENT STATIONS

J. T. JARDINE, W. H. EVANS, W. H. BEAL, G. HAINES, J. I. SCHULTE, SYBIL L. SMITH, R. W. TRULLINGER, B. YOUNGBLOOD

EXPERIMENT STATION RECORD

Editor: HOWARD LAWTON KNIGHT

Agricultural and Biological Chemistry—H. C. WATERMAN and SYBIL L. SMITH.
Agricultural Meteorology—W. H. BEAL.
Soils and Fertilizers—H. C. WATERMAN.
Agricultural Botany, Diseases of Plants—W. H. EVANS and W. E. BOYD.
Genetics—H. M. STEECE, J. W. WELLINGTON, and G. HAINES.
Field Crops—H. M. STEECE.
Horticulture, Forestry—J. W. WELLINGTON.
Economic Zoology and Entomology, Veterinary Medicine—W. A. HOOKER.
Animal Husbandry, Dairying, and Dairy Farming—H. W. MARSTON.
Agricultural Engineering—R. W. TRULLINGER.
Agricultural Economics and Rural Sociology, Agricultural and Home Economics Education—F. G. HARDEN.
Foods and Human Nutrition—SYBIL L. SMITH.
Textiles and Clothing—H. M. STEECE and SYBIL L. SMITH.
Home Management and Equipment— ——— ———.
Indexing—MARTHA C. GUNDLACH.
Bibliographies—CORA L. FELDKAMP.

DIVISION OF INSULAR STATIONS

W. H. EVANS, Chief

Alaska Stations, Juneau: H. W. ALBERTS, Director.
Guam Station, Guam: C. W. EDWARDS, Director.
Hawaii Station, Honolulu: J. M. WESTGATE, Director.
Puerto Rico Station, Mayaguez: T. B. MCCLELLAND, Director.
Virgin Islands Station, Christiansted, St. Croix: GLEN BRIGGS, Acting Director.

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF EXPERIMENT STATIONS

Washington, D. C. September, 1932

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1931

By J. T. Jardine, W. H. Beal, and H. M. Steece[1]

CONTENTS

INTRODUCTION

The purpose of this report is to show how the funds available for the support of the agricultural experiment stations in the several States and in Alaska, Hawaii, Puerto Rico, Guam, and the Virgin Islands during the year ended June 30, 1931, were used, and what were some of the more significant results of the work of the stations during the year. The report also gives information regarding personnel, facilities for research, projects and cooperation, publications, and other matters relating to the organization, administration, and progress of the work of the stations.

The year's record is one of substantial progress. The total income of the stations increased (p. 2) despite the unfavorable economic conditions generally prevailing throughout the country, and to an increasing extent the funds were restricted to specific projects providing for more intensive and productive research. The review on pages 11 to 108 furnishes evidence that the stations are making contributions of value to the science and practice of agriculture and the betterment of rural life.

FINANCIAL SUPPORT

The financial support of the experiment stations increased during the year, their total income being $18,056,282 as compared with $17,911,123 the previous year. Of the total, $4,340,000 ($90,000 to each State and $20,000 to Hawaii) was derived from Federal sources (Hatch, Adams, and Purnell funds) and the remainder from State and other sources, as shown in Table 1.

[1] With the collaboration of other members of the office staff.

125057—32——1

TABLE 1.—*Income of stations from all sources for the fiscal years 1930 and 1931*

	1930	1931
Hatch Act	$735,000.00	$735,000.00
Adams Act	720,000.00	725,000.00
Purnell Act	2,880,000.00	2,880,000.00
Appropriations for insular stations	247,000.00	250,200.00
State appropriations and allotments	8,807,105.20	9,166,554.19
Fees	644,462.36	630,455.23
Sales receipts	1,855,356.37	1,618,219.64
Miscellaneous income	596,276.76	548,613.58
Balance from previous year	1,425,923.16	1,502,239.43
Total	17,911,123.85	18,056,282.07
		17,911,123.85
Income 1931 over 1930		145,158.22

The table shows that $13,466,082 or 74.5 per cent of the total income of the stations for the year was derived from other than Federal sources. The distribution of these supplementary funds by States is shown in Table 2.

TABLE 2.—*Income of stations from other than Federal sources for the fiscal years 1930 and 1931*

Station	1930	1931
Alabama	$281,788.54	$259,113.15
Arizona	102,476.55	110,074.99
Arkansas	131,568.65	138,533.66
California	948,467.03	1,080,740.42
Colorado	180,688.64	173,372.11
Connecticut (State)	237,116.45	250,865.19
Connecticut (Storrs)	60,426.89	65,195.06
Delaware	41,133.39	41,100.32
Florida	441,143.50	497,548.66
Georgia	64,455.50	38,119.84
Hawaii	55,101.53	41,894.98
Idaho	59,141.21	52,930.31
Illinois	508,403.38	531,055.82
Indiana	741,952.97	759,186.89
Iowa	306,834.09	302,862.93
Kansas	223,344.78	197,373.50
Kentucky	362,227.18	400,437.70
Louisiana	207,244.08	187,128.92
Maine	77,220.17	87,105.04
Maryland	134,273.23	132,372.86
Massachusetts	283,717.19	291,540.29
Michigan	365,599.18	372,048.40
Minnesota	406,788.00	405,321.18
Mississippi	174,345.24	170,690.16
Missouri	189,445.74	176,061.98
Montana	161,959.51	148,239.98
Nebraska	220,695.47	240,869.43
Nevada	11,949.66	8,664.28
New Hampshire	49,138.34	55,769.45
New Jersey	543,058.95	894,178.75
New Mexico	38,194.20	61,321.20
New York (Cornell)	738,235.61	840,149.91
New York (State)	351,730.51	401,054.59
North Carolina	209,270.24	187,412.16
North Dakota	257,085.10	221,506.29
Ohio	1,392,882.03	1,051,913.48
Oklahoma	175,023.54	193,145.76
Oregon	318,439.96	293,103.54
Pennsylvania	154,983.08	163,497.29
Rhode Island	12,461.05	6,896.55
South Carolina	151,640.08	128,408.79
South Dakota	62,000.50	56,794.62
Tennessee	73,720.25	66,503.45
Texas	720,845.27	589,663.04
Utah	96,776.62	101,897.03
Vermont	22,913.99	24,197.86
Virginia	110,319.48	128,039.28
Washington	180,422.14	151,277.19
West Virginia	148,720.63	141,525.65
Wisconsin	440,441.55	449,745.84
Wyoming	101,312.98	97,632.30
Total from other than Federal sources	13,329,123.85	13,466,082.07
Federal funds	4,335,000.00	4,340,000.00
Grand total	17,664,123.85	17,806,082.07

The table shows that 24 stations reported increases and 27 decreases in supplementary funds. In a number of cases the increases were substantial, while in only a few cases were the decreases significant.

More detailed data on income and expenditures of the stations will be found on pages 133 to 146.

Cost of benefits.—Financial support of the experiment stations from Federal, State, and other sources has been liberal and amounts, in the aggregate, to a large sum. The annual cost of the experiment stations is, however, only about 15 cents per capita of the population of the United States, and the benefits from their work can be shown to far exceed their cost. Moreover, these benefits are not confined to the rural population, but accrue to all the people and all the industries of the country. On this point, W. H. Shepardson, a New York business man, who appears to have made a careful study of the subject, says: [2]

* * * The condition of agriculture is a national concern second to none. Food and raw materials come out of the land: industry and trade depend not only upon the assurance of an adequate supply of these raw materials, but upon the assurance of a prosperous rural market for finished products. The close relation between city and country, agriculture and industry, farmer and laborer is the economic and social foundation of the state.

Important reasons for public financing of agricultural research cited in the Survey of Land-Grant Colleges and Universities published by the United States Office of Education [3] are "the interest of the public in promoting unrestricted use of the findings of research which may reduce cost of production and distribution, improve quality, and insure supply of agricultural products" and "the difficulty of organizing agriculture for self-supporting research."

Agriculture is made up of many enterprises and activities engaged in by large numbers of individuals operating under a wide diversity of conditions. The problem of self-financing for agricultural research is made more difficult by the fact that findings from agricultural research are so difficult to control through patent or otherwise. A new crop, a new cultural method, new herd management, can not be monopolized and any agency other than the public would have difficulty in securing financial returns on the discovery sufficient to encourage further research. The public gets its return through decreased cost of living and from the increased purchasing power of agriculture.

[2] SHEPARDSON, W. H. AGRICULTURAL EDUCATION IN THE UNITED STATES. p. 2–3. New York. 1929.

[3] KLEIN, A. J. SURVEY OF LAND-GRANT COLLEGES AND UNIVERSITIES. U. S. Dept. Int., Off. Ed. Bul. 9 (1930), v. 2, pp. 611–612. 1930.

There is abundant evidence that station work is returning to the public many times its cost in improved methods of soil maintenance, better crop plants and methods of culture originated by the stations, more efficient methods of controlling insect pests and plant diseases, better methods of breeding, feeding, and management of farm animals, more effective control of animal diseases, better methods of farm management and marketing of farm products, and in many other ways. The results of station investigations on vitamins, mineral requirements in nutrition, and effect of light have had a profound influence on feeding and dietary practices; many improved varieties of crop plants, fruits, and vegetables have been originated or introduced by the experiment stations and the United States Department of Agriculture and have replaced older and less desirable varieties; the great wheat-growing industry of the United States is, to a large extent, based on improved varieties developed or introduced by the experiment stations and the Department of Agriculture; cotton growing has survived the boll weevil largely because of efficient methods of controlling the pest and improved methods of culture resulting from investigations by the stations and the department; orchard culture has been vastly improved as a result of investigations on cover crops, improved varieties, pruning, grafting, and spraying; the Babcock test and the improved methods which it made possible have revolutionized the dairy industry; and losses due to such destructive diseases of animals as infectious abortion in cattle, pullorum disease of fowls, and many others have been greatly reduced as a result of the work of the stations and the department.

FACILITIES FOR RESEARCH

The expanding activities of the experiment stations and the increasing complexity of their work call for constant improvement and extension of facilities for research.

During the past year many additions were made to lands, buildings, laboratories, and various special forms of station equipment. The total sum reported as expended for such purposes included $1,478,152 for buildings, $65,222 for library needs, $350,847 for scientific apparatus, $224,145 for farm implements and machinery, $151,193 for livestock, and $295,755 for miscellaneous items, aggregating $2,565,317

for additions to the general equipment and representing an increase of $275,918 over this expenditure for the preceding year.

BUILDINGS

The construction of a 4-story building to cost about $600,000 was begun at Cornell University toward the close of the year. This structure for the use of the department of agricultural economics and farm management and the department of rural social organization will be of direct benefit to the experiment station.

Capital outlay for permanent improvements at the New York State station included $65,000 for the equipment of the newly constructed horticultural building and $80,000 for greenhouses. The new horticultural building housing the departments of pomology, botany, and vegetable crops, supplies better laboratory facilities for horticultural investigation. The new greenhouses afford greater opportunities for experiments with plants and for the study of soils.

A horticultural building, a 3-story brick structure, for the use of both college and experiment station, was under construction at the University of Maryland.

The new agricultural building of the New Mexico college, completed and occupied during the year by the departments of biology, agronomy, animal husbandry, poultry husbandry, and horticulture, and the office of the director of the experiment station, furnishes much-needed facilities for research.

An agricultural engineering building erected at the Kentucky station at a cost of $75,000 includes among other features laboratories for work on concrete, farm motors and other farm machinery, farm buildings, crop drying, and other experiments of the station.

The animal husbandry building used by the Nebraska college and experiment station, partly destroyed by fire in the spring of 1931, was replaced with a fireproof structure at a cost of $75,000.

A laboratory building with three floors and basement, to be used for work in entomology, botany, plant breeding, and forestry was provided for the agricultural college and experiment station at Storrs, Conn. This building is to cost $65,000, of which the State is to furnish $25,000 and the remainder is to come from surplus funds derived from feed and fertilizer control work.

A dairy barn and experimental plant to cost $60,000 and laboratory equipment, including a temperature-control installation for different lines of experiment station work, to cost about $40,000, were provided for by the Kansas Legislature.

A meat laboratory for both college and station use was provided for by an appropriation of $22,500 by the Oklahoma Legislature.

A very complete textile-testing laboratory equipped with automatically controlled air-conditioning devices was installed at the South Carolina station. Facilities for research with textiles were also greatly improved at the Minnesota station by the installation of a well-equipped conditioning room in the home economics building for research and tests requiring constant atmospheric conditions.

An entomological laboratory with facilities for the study of citrus insects and their control was constructed near Mobile, Ala., with the aid of the State Board of Agriculture and the city of Mobile, to be operated by the Alabama station.

A laboratory for research on dates was erected during the year by the Arizona station at Tempe.

A building arranged for the study of anaplasmosis and sterility of cows in the Everglades section was completed at West Palm Beach for the use of the Florida station.

A refrigeration plant costing about $18,000 and containing six storage rooms and two freezing rooms with automatic-control apparatus for studying the storage requirements of fruit, fruit juices, fruit pulps, and other materials was constructed at the Florida station.

A new house well equipped for work with small experimental animals was built at the Kentucky station at a cost of $17,600. Other improvements, provided for the station by State appropriations, included a beef-cattle barn to cost $15,000, a piggery to cost $4,500, and a dwelling on the poultry farm to cost $3,200.

The erection and equipment of a farm-crops field house at the Minnesota station was provided for by a State appropriation of $30,000.

State appropriations for permanent improvements at the New Jersey stations included $10,000 for enlarging the plant physiology building, $12,000 for a livestock barn, $15,000 for horse barns, $9,000 for improved greenhouse and other horticultural facilities, and $1,200 for automatic refrigeration in the dairy building.

Appropriations for improvements at the Oklahoma station, made by the State legislature, were as follows: $18,500 for a new horse barn, $5,600 for barns and experimental-feeding sheds, and $13,500 for the improvement of roads and fences on the college and station farms.

Permanent improvements at the Maine station included a new poultry plant and outside poultry shelters costing about $33,600.

A small but well-equipped building for nutrition experiments with dairy cows was constructed at the South Carolina station.

Special State appropriations provided $1,500 for waterworks and fencing, and $8,000 for general improvements at the Mississippi station.

LAND AND SUBSTATIONS

The purchase of a pear orchard near Medford for the use of the Oregon station in work on pear production and preparation for marketing was made possible by local subscriptions amounting to $25,000.

At the newly established Texas substation No. 19, known as the Winter Garden station, at Winter Haven, improvements included an electrically operated pump delivering 900 gallons of water per minute and buildings for the accommodation of employees and office and laboratory work. At substation No. 15, at Weslaco, a laboratory building for the study of problems in horticulture, entomology, and plant pathology was erected during the year. Substation No. 2, at Troup, was relocated in the same county, so that it might be operated in connection with the soil-erosion station where the State has 455.2 acres of land for soil-erosion work in cooperation with this department.

The management of a group of five farms in Sussex County, N. J., aggregating 1,100 acres, with about 280 head of Holstein and Guernsey cattle and a full equipment of buildings and other facilities, was taken over by the New Jersey station May 15, 1931. This property, given to the station for experimental purposes, was organized as the James Turner Institute of Research and so named in honor of the donor. The last State legislature appropriated $80,000 for improvements, especially laboratories, and for maintenance. These farms with their equipment are to be operated as a dairy-research station and the work contemplated includes breeding cattle for milk production, cattle feeding, control of diseases, and economic management.

Among other acquisitions of land for experimental purposes were the purchase, for the cotton substation in Arkansas, of a tract of 89 acres, together with livestock and machinery, including a cotton gin with all accessories; the lease by the Missouri experiment station of 200 acres at Bethany for soil-erosion studies, 220 acres at Columbia for cereal breeding, 120 acres at Green Ridge for mountain-pasture experiments, and 50 acres at Sikeston for bottom-land reclamation work; the lease by the University of Wisconsin of a farm of 120 acres near the present holdings, to provide for additions to the poultry-research plant; the securing for the substation at Scottsbluff, Nebr., of a tract of 160 acres, including about 65 acres of irrigated land and from 30 to 40 acres capable of being irrigated, to supplement the original 160 acres now in use; a gift to the North Carolina College of Agriculture of 721 acres of land in addition to a previous donation of 370 acres for forestry work; and the securing at a cost of $9,000 of additional land for the fruit farm near Zumbra Heights, Minn.

In further development of the experimental work with sheep at Fort Ellis, near Bozeman, Mont., a new horse barn was completed and a dwelling and a large sheep shed were under construction. Electricity was made available and a complete water system was installed.

A residence was built at the new substation near Yuma, Ariz., where pecan investigations on a considerable scale are to be undertaken.

A fireproof office and laboratory building, a greenhouse, and other structures, costing about $90,000, were built at the Everglades substation in Florida.

An office and a laboratory building, costing $10,000, were erected at the Princeton substation in Kentucky. An office building and a laboratory were erected at the Fort Hays branch station and a dairy building at the Colby branch station in Kansas.

A State appropriation provided $37,500 for an office building at the Delta branch station, Mississippi, and $13,500 for an office building and laboratory at the fruit farm near Zumbra Heights, Minn.

MISCELLANEOUS IMPROVEMENTS

Additions of various kinds of equipment, general improvements, increases

in herds of livestock, and provisions for special work were reported by a number of institutions.

On the New Mexico college livestock ranch a 63,000-gallon steel watering tank with about 2.5 miles of pipe leading from it, a large stock scale and scale house, and other accessory equipment for use in experiments on supplemental range feeding of beef cattle were installed.

A new water system supplying also the horticulture and poultry farm units and having a pump capacity of 15 gallons per minute and a storage capacity of 3,000 gallons was completed on the West Virginia experiment station dairy farm.

A milk house and a hay-drying machine costing about $4,000 were added to the equipment of the Vermont station.

A gift of 50 cows and 2 bulls of purebred Holstein cattle was received by the Missouri station, as an addition to its dairy herd, and the department of animal husbandry of the New York College of Agriculture was granted a State appropriation of $65,000 for the purchase of new foundation breeding animals.

STATION PROJECTS

Practically all of the work of the experiment stations is conducted on a project basis. Much thought and care are given to planning projects and research programs with a view to securing more systematic and ordered research.

The formulation of projects has been discussed in a previous report of this series[4] and in reports of the committee on station organization and policy of the Association of Land-Grant Colleges and Universities.[5] The last report of the committee on station organization and policy says: "While the project outline is not a thing to be standardized, it may properly be expected to conform to certain essentials which experience and good usage have disclosed." The report suggests the following as "the minimum of such essentials for an acceptable project:"

(1) A clear-cut specific title, accurately characterizing the work to be undertaken.

(2) The leaders and cooperators in the project.

(3) Clearly defined objectives.

(4) An explicit statement of procedure to be followed.

(5) Evidence of familiarity with work of others on the subject.

(6) Allotment of funds.

The report says further:

> The precise and complete form and content of a project outline applicable to all cases would be difficult to prescribe, but adequate and definite information on points one to six enumerated is essential in passing judgment on projects submitted for approval. It is believed that the handling of projects by the Office of Experiment Stations as well as by station directors would be simplified and expedited if these requirements and suggestions are consistently adhered to in formulating the project outline.

During the past year an unusual amount of attention was given to revising projects and recasting research programs. Projects, particularly those supported by Adams and Purnell funds, were made more specific in plan and purpose, many were completed and closed, and research programs were relieved of unprogressive and unproductive projects. More discrimination than heretofore is also being exercised in selecting problems for study.

At the close of the year ended June 30, 1931, there were 398 active Adams projects and 1,241 Purnell projects. During the year 21 new projects were added to the Adams list, 14 were revised, and 28 were completed. During the same period 179 new projects were added to the Purnell list, 47 were revised, and 128 were completed or dropped.

The 398 Adams projects active at the close of the year were distributed by major subjects approximately as follows: Plant diseases, 69; soils and fertilizers, 54; entomology and zoology, 46; genetics, 44; horticulture, 38; veterinary science, 37; animal production, 33; field crops, 25; plant physiology, 14; dairying, 11; chemistry, 9; home economics, 7; agricultural engineering, 6; pasture and ranges, 3; and forestry, 2.

The 1,241 Purnell projects were distributed by major subjects approximately as follows: Agricultural economics, 292; animal production, 140; home economics, 123; horticulture, 107; plant diseases, 87; field crops, 82; entomology and zoology, 81; soils and fertilizers, 63; agricultural engineer-

---

[4] ALLEN, E. W., et al. U. S. Dept. Agr., Off. Expt. Stas., Rpt. Agr. Expt. Stas. 1927: 11–12. 1928.

[5] JARDINE, J. T., et al. REPORT OF THE COMMITTEE ON EXPERIMENT STATION ORGANIZATION AND POLICY. Assoc. Land-Grant Cols. and Univs. Proc. (1927) 41: 196–197. 1928.

SLATE, W. L., Jr., et al. REPORT OF THE COMMITTEE ON EXPERIMENT STATION ORGANIZATION AND POLICY. Assoc. Land-Grant Cols. and Univs. Proc. (1931) 45: 264–266. 1932.

ing, 59; veterinary science, 54; dairying, 50; genetics, 37; rural sociology, 29; pastures and ranges, 16; plant physiology, 12; chemistry, 5; and forestry, 4.

The Adams and Purnell projects cover the major fields of research in agriculture and home economics. The Adams projects deal primarily with fundamental research on problems of production. The Purnell projects take a wider range and include also research in agricultural economics, rural sociology, and home economics, which together account for over one-third of the total number of projects supported with Purnell funds.

ECONOMIC AND SOCIOLOGICAL RESEARCH

In the report for 1930 [6] attention was called to the marked development of research in agricultural economics and rural sociology during the first five years that the Purnell fund was available. The extent of such development was apparent in the fact that 29 per cent of all projects supported by the Purnell fund were in the field of farm management and agricultural economics. A further review of station projects and expenditures shows that approximately 48 per cent of the aggregate Purnell fund available up to June 30, 1931, was spent for research in agricultural economics, rural sociology, and home economics.

Further advance was made during the past year especially in the preparation of the specialists engaged, the methods employed, and the scope of the programs evolved by the State stations and Federal bureaus, either jointly or separately. More and more, the forces of agricultural research are coming to appreciate the fact that, beyond their local and individual significance, rural economic and social problems are regional, national, and even international in scope. It is being recognized, therefore, that their solution requires teamwork in both thought and action on a scale little dreamed of before the establishment of the Federal Bureau of Agricultural Economics and the passage of the Purnell Act.

Though the number of specialists in rural sociological research only remained constant during the year, the number engaged in agricultural economics research increased from 250 in 1929–30 to 280 in 1930–31—a gain of about 12 per cent.

[6] YOUNGBLOOD, B. ECONOMICS AND SOCIOLOGY. U. S. Dept. Agr., Off. Expt. Stas., Rpt. Agr. Expt. Stas. 1930: 2–3. 1931.

In harmony with the view that success in research depends largely upon creative minds, trained and organized for the scientific solution of practical problems, the specialists made satisfactory progress in advancing their professional degrees. In 1929–30, there were 60 specialists in agricultural economics research holding the degree of doctor of philosophy or its equivalent, whereas in 1930–31, there were 77, an increase of about 28 per cent. The number holding a master's degree increased from 126 to 134, or slightly more than 6 per cent. The number holding a bachelor's degree declined from 65 to 64, and those holding no degrees from 5 to 4.

With the increases in numbers of projects and in amounts of available funds have come decided improvements in projecting research. Because of the unusual demand for specialists in these newer fields, economic and sociological projects were too frequently entrusted to unseasoned talent, and many of the earlier projects were hastily and imperfectly prepared and entered into. Then, too, difficulties were encountered in the scientific methods employed. For these reasons, it was necessary to revise or restate many such projects after considerable research upon the methods to be employed. Remarkable progress has been made in matters of sampling and interpretation. Statistical method has been greatly improved.

Comparing 1929–30 with 1930–31, the number of active projects in agricultural economics at the stations declined from 338 in the former year to 331 in the latter—a net decline of 7 projects. These fewer projects in 1930–31 actually received more funds than did the greater number of projects active in 1929–30. In 1929–30 agricultural economics projects received $780,173, whereas in 1930–31 they received $812,956 of the Purnell fund—an increase of about 4 per cent. Similar increases also occurred in State funds assigned to these projects.

In agricultural economics research the present tendency is to secure basic information leading to forward-looking adjustments based in part upon the suitability of individual farmers and their farms to the production of particular products and in part upon the prospective demand for these products. More attention than heretofore is also being paid to the capacity of individual farmers who operate particular types of farms.

Between 1929–30 and 1930–31 the number of active projects in rural so-

ciology declined from 41 to 36 and the Purnell funds assigned to them decreased from $91,000 to $85,340. Though there was an actual decline in dollars received, the average support per project was increased. In this field, the tendency has been to evolve from the more general type of inquiry or survey earlier employed to a more scientific and statistical attack upon specific problems. Meantime, much valuable research has been devoted to methods.

From another viewpoint, the trend has been from contemporary or cross-section to historical studies. In point of intensity, the studies of this group have evolved from the community to the locality and, more recently, to the individual family. More study is being devoted to standards of living as reflected in farm-family incomes and expenditures. Just now there is considerable interest among sociological research workers in analyses of farm families, taking the individual members of the family as the units of study. As soon as satisfactory methods of research can be developed, this more intensive type of study of the farm family will, doubtless, become more general.

A review of 120 station publications reporting investigations in agricultural economics shows that 43 dealt with farm-management problems, 4 with costs of production, 30 with marketing, 9 with prices, 2 with statistics, 4 with farm income, 1 with cooperation, 8 with agricultural finance, 5 with farm taxation, 6 with land economics, 2 with trade areas, and 6 with miscellaneous subjects. Of 23 rural sociology bulletins received, 5 dealt with costs and standards of living, 3 with rural population, 1 with social groups, 7 with rural institutions and organizations, and 7 with miscellaneous subjects.

The world-wide depression has emphasized, probably more than anything else, the need for more comprehensive programs of research, whether carried on severally or jointly by the State experiment stations and the Federal Department of Agriculture. Illustrations of the tendency toward broadening and strengthening coordinated effort in the fields of agricultural economics and rural sociology are not lacking. For example, the economic and social study of the problems of the southern Appalachian highlands may be cited. This program is participated in and financed by the agricultural experiment stations of the States of Kentucky, North Carolina, Tennessee, Virginia, and West Virginia, the Federal bureaus of Agricultural Economics, Home Economics, and Forest Service, the Office of Education, and independent educational and religious organizations. Leadership was provided for the program when the cooperative group selected one of its number, L. C. Gray, of the Federal Bureau of Agricultural Economics, as director of research. As designed, the program will require three years for completion—one year for gathering data of basic importance to all the projects included in the program, another year for the intensive studies provided for, and a third year for the interpretation of data and preparation of a manuscript for publication.

From this rather extensive undertaking, it is expected that the workers will secure valuable experience in correlating research in the social fields and that the conclusions drawn will form a well-organized body of information which should be helpful in making practical adjustments in the economic and social affairs of the rural people of the southern Appalachian highlands.

Still another, and probably the latest, development in cooperation is a tendency to correlate natural-science researches with economic and sociological researches. The underlying thought is that as the specialists working in the physical and biological fields provide the "sand and gravel, cement and steel" to pave the way, specialists in the fields of agricultural economics and rural sociology will furnish the plans and specifications for better farm incomes and standards of living. Thus, the different types of scientific research are coming to be integrated into more effectual units.

B. Youngblood.

COOPERATION

Cooperation between groups of stations having common problems, between the stations and other State agencies, and between the stations and the Federal Department of Agriculture, made distinct progress during the year. This is shown not in number of cooperative agreements entered into, but in the refinement of the projects involved, the rounding out of research programs, and the more discriminating selection of problems for study.

The total number of cooperative agreements in which the department

and the experiment stations took part during the year, as recorded in the Office of Experiment Stations, was 987. This is 189 or 16 per cent fewer than during the previous year. This decrease in number of agreements may, however, be attributed not to declining interest in cooperation, but to completion of certain studies and revision of research programs resulting in consolidation of several cooperative studies into larger undertakings of broader significance as, for example, in the various cooperative studies on meat and in other important problems.

All of the experiment stations cooperated with bureaus of the department during the year, the number of cooperative agreements per station ranging from 2 to 59. The Bureau of Plant Industry had 374 cooperative agreements with the stations as compared with 398 the previous year; Bureau of Agricultural Economics, 173, compared with 311; Bureau of Animal Industry, 111, compared with 134; Bureau of Chemistry and Soils, 96, compared with 88; Bureau of Agricultural Engineering, 76, compared with 68; Bureau of Entomology, 64, compared with 86; Bureau of Dairy Industry, 40, compared with 50; Forest Service, 36, compared with 25; Bureau of Home Economics, 11, compared with 10; Weather Bureau, 3, compared with 6; Bureau of Biological Survey, 3, compared with none the previous year.

There were 10 lines of work in which more than 3 stations cooperated with bureaus of the department as follows: Factors which influence the quality and palatability of meat, 22 stations; relation of conformation and anatomy of the dairy cow to her producing ability, 15; corn improvement, 12; possibility of increasing production of red-clover seed in the intermountain States, 7; utilization and cost of farm power, 7; continuous use of proved sires to breed dairy cattle of high milk and butterfat production capacity, 5; virus diseases of potatoes, 4; oil spray, 4; growth of wool, 4; and alfalfa weevil, 4 stations.

Many of the cooperative undertakings are regional in scope, involving cooperation of a number of stations as well as bureaus of the department. A significant development in such regional cooperative effort during the year was the formulation of the extensive study of interrelated farm and home, educational, and rural-life problems of the southern Appalachian highlands, already referred to (p. 8).

A large cooperative enterprise, national in scope, in which the department and an increasing number of experiment stations have been engaged for several years, is the study of factors affecting the quality and palatability of meat. This study, in which 22 stations are now cooperating with the Bureaus of Animal Industry, Home Economics, and Agricultural Economics, was organized shortly after the passage of the Purnell Act in 1925. In planning it provision was made for extensive and thoroughgoing investigation in a field in which little attention had previously been given to the quality of the finished product. Methods of grading, feeding, slaughtering, cutting, cooking, chemical and physical analysis, and judging the quality and palatability of the meat have been perfected and standardized for the use of the various cooperators. (See also pp. 55, 75.)

The study at first centered on beef, but has since been extended to include other meats. It has advanced to a stage at which interpretation of data from many correlated investigations is yielding results and conclusions having broad scientific significance and practical application. For example, it has been found that retarded growth lowers palatability of meat; that there are no marked differences in palatability of the meat of different breeds, although there are striking differences in composition and palatability of meat from individual animals of the same breed, which fact indicates the desirability of selecting and breeding for quality of meat; that the grade of the carcass is closely related to the thickness of the external fat or the degree of finish, indicating the importance of securing the minimum degree of finish that will produce the necessary yield and market quality; that feeding grain to well-bred suckling calves is advantageous from the standpoints of grade of carcass and quality of meat.

The widespread and long-continued cooperative study of meats has served particularly to direct attention to the importance of quality in meat and to develop reliable standards and methods of determining and producing quality, and to indicate the possibilities of cooperative research on a large scale.

In addition to the cooperation between the experiment stations and the department that have been noted, there were 31 interstation cooperative agreements in which the department did not take part. Cooperation of experiment stations with other State

agencies is also effective in a number of States. Complete and up-to-date information on this point is not available, but the Survey of Land-Grant Colleges and Universities, based on data for 1928, reports[7] 10 institutions having a total of 42 projects in cooperation with 12 different State agencies. Twenty of these projects were in cooperation with State departments of agriculture or corresponding offices; 5 with the State plant board; 3 with departments of institutions and business management; 2 with food and drug commissions; 2 with commissions on conservation and development; 2 with livestock sanitary boards; 2 with the State bureau of markets; 1 with the fish and game commission.

The subjects under cooperative study include plant and animal pests, sanitation, quality and grading of products, tests of flour, milling and baking, crop varieties, seeds, feeds, dairy products, storage of potatoes, drainage, irrigation, oyster propagation, timber growth, fertilizers, fumigation, water pollution and sewage disposal, and removal of spray residue from fruits. This list is not complete but indicates cooperation under way which appears to be extremely profitable.

Complete solution of many of the problems with which the experiment stations have to deal requires the active cooperation of various specialists. Recognition of this fact has resulted in a marked increase in projects enlisting the services of more than one specialist within the station, as well as of specialists of other stations and research agencies. The cooperation thus begins within the station staff, then becomes regional, then national in scope, with great gain in effectiveness and in development of cooperative spirit. Much cooperation is not a matter of formal agreement or record but is nevertheless contributing very effectively to the solution of many important problems.

THE MISSISSIPPI EXPERIMENT STATION

During the year there developed in the administration of the four major State educational institutions of Mississippi a situation which resulted in suspension of these institutions from the list of accredited educational institutions by national and local organizations dealing with such matters. In the words of the executive committee of the Association of Colleges and Secondary Schools of the Southern States, this was due to "wholesale dropping of scores of officers and teachers from the suspended schools without warning, without charges, and without opportunity of defense." The conditions thus created seriously affected the agricultural experiment station connected with the Agricultural and Mechanical College.

The actual or proposed changes in personnel directly affecting the experiment station included the director, heads of four departments, several research associates, the accounting staff, and practically the entire skilled-labor and clerical forces of the station. Among these were leaders of important research projects supported by Federal funds. The feeling of uncertainty and instability engendered led several other workers in key positions on the staff to seek positions elsewhere, among the resulting resignations being those of the heads of the departments of agricultural engineering and animal husbandry and the research associate in horticulture.

The potential menace to the ability of the experiment station to make proper and effective use of Federal funds prompted the department to intervene in order to prevent unwarranted changes in the station staff and to aid in rehabilitating the station organization and program. A representative of the Office of Experiment Stations conferred with the State Board of Trustees of the Colleges and the University and fully explained the position of the department with reference to changes in personnel tending to lower morale and to disrupt the research program of the station and the importance of maintaining a well-trained and experienced personnel in uninterrupted service, especially in key positions. Following this conference and subsequent negotiations, the board appointed a thoroughly competent director and gave him full authority and responsibility for the management of the station. Several members of the station staff who had been dismissed were reinstated and other vacancies eventually were filled with competent employees.

Federal funds were not available for the use of the station during the readjustment of its affairs. The treasurer of the college to whom warrants for the Federal funds had formerly been drawn had been removed from office and an act of the State legislature had designated the State treasurer as the recipient of all funds coming to the State. The Comptroller General of the United States ruled that payment of the Federal funds for

[7] KLEIN, A. J. Op. cit., p. 601. (See footnote 3.)

the experiment station could be made only to an officer of the experiment station duly appointed by the governing board of the institution, and that the State treasurer was not such an officer. When this ruling was called to the attention of the State authorities, a recipient of the funds conforming to the requirement was designated by the board and the Federal funds became available for the use of the station. With the funds thus made available and the reestablishment of a competent administrative and research personnel, the station gradually resumed its normal state of activity, not, however, without serious retardation of its research program.

INSULAR EXPERIMENT STATIONS

The main purpose of the experiment stations maintained by the United States Department of Agriculture in Alaska, Hawaii, Puerto Rico, Guam, and the Virgin Islands is to diversify the agriculture of the several regions and to make it more efficient and self-sustaining. The stations are working mainly on local problems, but the results of their investigations have a wider application, as is shown by the re-publication of several of their bulletins in other countries.

INCOME

The incomes of the stations derived from appropriations made by Congress for the fiscal year ended June 30, 1931, were as follows: Alaska, $85,300; Hawaii, $45,200; Puerto Rico, $59,200; Guam, $30,200; and the Virgin Islands, $30,300. The above income of the Virgin Islands station was increased by $16,700 transferred from an appropriation made by Congress for the temporary government of the islands. The proceeds from the sale of products, which were deposited in the Treasury as miscellaneous receipts and were not available for station use, amounted to $4,796.55.

SOME SIGNIFICANT SERVICES OF THE STATIONS

Some of the conspicuous achievements of the stations in aiding the development of the agriculture of the regions served by them are given below.

Alaska stations.—The Alaska stations, through hybridizing and selection, have developed varieties of wheat, oats, and barley that ripen within normal summers in the interior of Alaska.

The possibility of small-fruit growing has been demonstrated, and currants and gooseberries are now quite generally grown. By hybridizing the native wild strawberry with a commercial variety, winter-hardy strawberries of excellent quality are being grown extensively in many parts of the Territory.

Potato seedling varieties and selections of good quality are grown in quantity. The turnip variety Petrowski, an introduction of the stations, is the most common variety grown. It is of excellent quality and is less attacked by insects than is any other known variety.

Hardy varieties of most vegetables adapted to the Territory have been tested and recommended by the stations.

The stations proved the hardiness of Galloway cattle in southwestern Alaska and the interior, and through crossbreeding the Galloway and Holstein breeds a hardy strain of milk cow has been produced that gives more milk than the average of the Galloway herd and a higher fat content than the Holstein herd. One crossbred cow produced over 12,000 pounds of milk in her fourth lactation period, and each of several second-generation crosses gave over 8,000 pounds of milk in her first lactation. The crossbred animals are perfectly hardy in interior Alaska.

A breeding experiment in which the yak and Galloway cattle were crossed has given a good beef-type animal that is exceedingly hardy, crossbred animals that spent the winter on the open range coming out in good condition in the spring.

In livestock feeding the station found that mixtures of oats and peas or oats and vetch produced greater yields of forage of higher quality than did either crop grown alone.

Hawaii station.—The Hawaii station early in its activity began experiments with grasses and other forage plants with a view to improving the ranges, and it was responsible for the extensive areas of permanent pastures of *Paspalum dilatatum* on various ranges. It introduced and distributed Uba cane, Napier grass, Guatemala grass, and Sudan grass for soiling purposes. It developed the pigeon pea as a green-manure, soiling, hay, and pasture crop, and also produced strains of pigeon peas adapted to special uses. Probably 10,000 acres are now devoted to that crop. A strain of cowpea developed by the station is extensively

grown as a green-manuring and forage crop.

For a number of years the station carried on investigations with pineapples. It pointed out the value of rotating pineapples with a green-manure cover crop, a practice widely followed at this time. The possibilities of selection within the variety Smooth Cayenne, in order to secure more uniform shape, was early demonstrated. The cause and means of control of chlorosis of pineapples in Hawaii were discovered. The cause is the presence of toxic quantities of manganese in the soil and the means of control is spraying the plants with a solution of iron sulphate. So successful has been the treatment that it is followed on practically every plantation, and an industry that was threatened with destruction in 1916 produced in 1929 over 9,200,000 cases of packed pineapples valued at $39,880,000.

In experiments in rice culture, ammonium sulphate was found superior to sodium nitrate as a fertilizer for rice in Hawaii, and as a result the use of sodium nitrate for that purpose has practically been abandoned.

The station developed the use of sodium arsenite for the control of weeds in cane fields and along roads in fields, and its use is quite general.

Analyses of more than 800 samples of soils laid the basis for soil classification in the Hawaiian Islands.

Agronomic and chemical studies of the edible canna made possible the development of a canna-starch industry to supplement the agriculture of regions not suited to sugarcane or pineapples. Chemical and other studies have shown that Hawaii-grown fruits and vegetables are not deficient in iron and vitamins as had been claimed.

The horticultural work has taken a wide range. The station introduced into Hawaii the Gros Michel banana, the best commercial variety known, and aided in its development. Fertilizer experiments showed the proper treatment of the banana plant and investigations on the banana freckle disease showed its cause and means of control. The commercial growing of the Macadamia nut is a result of the station's investigations, and more than 300 acres have been planted to this crop in one district on the island of Hawaii. More successful and rapid methods for the propagation of many tropical fruit trees and other plants have been developed by the station.

The work in introducing, propagating, and distributing improved varieties of fruits, vegetables, forage plants, and root and other crops has been very extensive, and many of the varieties now commonly grown came from the station.

Puerto Rico station.—Almost at its establishment the Puerto Rico station began efforts to improve the livestock and crops of the island. It introduced purebred sires, used them to improve the station's stock, and loaned some of them to farmers for free service. In this way the possibility of improving all classes of livestock was soon demonstrated. In connection with this work it was quickly learned that the cattle tick was an important factor, and the first dipping vat in Puerto Rico was constructed at the station and the station property cleared of ticks. There are now nearly 100 private and public dipping vats in use in various parts of the island. The first silo for preserving forage for the dry season was constructed by the station, and there are numerous silos now on the plantations.

With the improvement of livestock the need for better forage plants was recognized, and the station turned its attention to introducing, testing, and disseminating forage plants from other tropical countries. Among the most striking results were the introduction of Napier grass or elephant grass, and Guatemala grass, either of which yields much more forage than the native grasses. They are now the mainstay of the dairy industry of the island. Molasses grass, the most productive grass for lowlands, was introduced and disseminated by the station. The station introduced the cultivation of the nonsaccharine sorghums which produce well during the dry season and yield grain for cattle and poultry feeding.

Considerable work with the parasites of livestock has been done, and the life history and data on control of the liver fluke and kidney worm under Puerto Rican conditions have been secured.

The station introduced colonies of Italian bees from which the local apiary industry was developed. Exports of honey and wax amounted in 1930 to almost $70,000.

The station introduced and aided in establishing the commercial production of vanilla. One planter, from an area of only a few acres, sold vanilla valued at over $13,000 in one season.

Much attention has been given to coffee investigations, including seedbed management, transplanting, spacing, pruning, fertilizing, shading, varieties, and insect and fungus pests.

The method of seed-bed management developed by the station is almost universally followed throughout the island. Potash fertilization was found to be necessary to increase production. An introduced variety, Excelsa, which is of outstanding merit, has been extensively distributed for planting. The knowledge on coffee obtained was of great importance in restoring the coffee plantations devastated by the hurricane of September, 1928.

Experiments with coconuts have shown that the application of fertilizers is of doubtful value. Cultivation, green-manure crops, and selection for productivity appear to be the most promising means of increasing yields.

Consideration has been given to vegetable growing and improved methods and varieties for Puerto Rican conditions have been established. This information is the basis for the present activity in producing vegetables for local use as well as for shipment to the mainland during the winter.

The citrus and pineapple industries, which in 1930 exported fruit valued at more than $7,250,000, owe much to the stimulus given by the station and its investigations on stocks, varieties, culture, diseases and insect pests, and methods of marketing.

The station was the pioneer in sugarcane breeding and testing in Puerto Rico. It developed a method for rapidly increasing planting material for testing and many plantations owe their possession of improved varieties of cane to the station. When the mosaic disease threatened the sugar industry in Puerto Rico the presence of Uba cane in the station collection of varieties led to the discovery of the resistance of this variety to the disease, and Uba cane was distributed widely and for a time supplanted susceptible varieties on many plantations. Breeding experiments were begun in which hybrids that carry in their constitutions the factor of resistance were made, and there are now under cooperative tests more than 600 acres planted to station-produced hybrids. Several of these are considered very promising.

Corn-breeding work has given important results, and the station has produced strains that greatly outyield the parent varieties.

Guam station.—The Guam station, although having only limited personnel and equipment, has been of great service to that island.

Through its importation of pure-bred horses, cattle, swine, and poultry, the general character of the livestock of the island has been greatly improved. Plant introduction and testing have resulted in the establishment of many economic plants that were unknown to the people. Napier and Guatemala grasses among soiling crops; *Paspalum dilatatum* for pasture; cowpeas, soybeans, pigeon peas, and improved strains of mung beans among leguminous crops; improved varieties of taro, yams, and sweet-potatoes among root crops; and a large number of varieties of fruits and vegetables have been added to the limited number previously grown. Better methods of crop cultivation are being adopted by the people as a result of the station work.

Copra is practically the only export crop of the island, and as a consequence the station has given much attention to coconut production and the making of copra. Improved methods of preparing copra have resulted in higher prices for the product. A few years ago coconut growing in Guam was threatened with destruction by the coconut scale. Through the efforts of the station, parasites and predatory enemies of the scale were discovered, bred, and distributed throughout the coconut groves, and now a biological balance has been established between the scale and its enemies and little damage is being done to the trees. Recently it has become a practice to extract the oil from the copra in Guam, and the press cake is left as a by-product. Experiments of the station have shown that the coconut meal can be substituted for about 25 per cent of the concentrate ration fed to all kinds of stock. This finding has resulted in a market for the meal, which is much cheaper than imported concentrates, and the rapid extension of its use locally.

Extension work, an important activity in any backward or undeveloped community, has yielded some excellent results. The work with adults has led to the adoption of better agricultural practices and marked improvement of the livestock of the island. Among children, keen interest has been aroused in club work, and within a year after the resumption of this activity about one-third of the children of school age were enrolled in garden, pig, and chicken clubs. In nearly every community fairs held annually in connection with club work have aroused great interest among children and adults. The effect of this work on the coming generation of farmers can not be other than beneficial.

Virgin Islands station.—The Virgin Islands station has yielded results of great importance to the islands, and in some cases valuable to other regions.

The sugarcane-breeding work has yielded one variety, S. C. 12/4, that is the best cane for St. Croix where the crop is grown without irrigation, and has largely supplanted all other varieties. It has been widely distributed and is being grown successfully in Cuba, Puerto Rico, and other West Indian islands. This cane is used in Puerto Rico as one of the standard varieties with which new varieties are compared and in 1930 it was one of the varieties most in demand for planting in that island. It is also used extensively in breeding work, and has entered into a large number of the new varieties that are under test.

The station has shown that level culture of cane is more economical, conserves moisture better, and gives better yields than the bedding system that has been quite commonly employed.

The sweetpotato commonly flowers and produces seed in the Virgin Islands. The station took advantage of this to produce a large number of seedling varieties. One of these is outstanding in quality and yields nearly twice as much as the standard variety grown in the islands. This new variety is now quite commonly grown.

The station has investigated the possibility of growing vegetables for local consumption and for shipment to New York during the winter season in order to provide additional agricultural industries. The local-consumption objective was attained, as is shown by the largely increased number of gardens. The export project was fairly successful so far as production was concerned, but irregular transportation and lack of storage facilities made the venture unprofitable.

PROGRESS DURING THE PAST YEAR

Following is a summary of the current activities of the stations:

Alaska stations.—The most important administrative events connected with the Alaska stations during the year were the transfer of the station near Fairbanks to the Alaska Agricultural College and School of Mines and the closing of the station on Kodiak Island.

By act of Congress approved February 23, 1929, the Hatch Act was provisionally extended to Alaska. By an act approved February 23, 1931, the Secretary of Agriculture was authorized to turn over to the Alaska Agricultural College the buildings, lands, and such equipment as was not needed at the other experiment stations maintained by this department in Alaska, and an appropriation of $15,000 was made for the support of the station. The legislature of Alaska had provided a small fund for station operation and on May 1, 1931, the station was formally turned over to the president of the college. G. W. Gasser, formerly connected with the Rampart and Fairbanks stations, was appointed director of the college station. F. L. Higgins, who had been in charge of the Fairbanks station for about three years, was transferred to the Matanuska station and placed in charge of the work in agronomy and plant breeding. The Fairbanks station had been maintained by the department for more than 20 years, and had demonstrated the agricultural possibilities of large areas in the Tanana and Yukon Valleys, where summers are short and the average rainfall is about 12 inches.

The Kalsin Bay station on Kodiak Island was closed June 15, 1931, a reduction in the appropriation not permitting its further operation. The work on Kodiak Island had been mainly with livestock and, except for two years following the eruption of Mount Katmai in 1912 when all pastures were destroyed, the work had been continuous since 1907. The principal problem was the winter management of livestock. It was shown that cattle and sheep could be maintained on pastures for about nine months of the year and overwintered on hay or silage made from native grasses growing on tidal flats and other areas. Protection against the cold winter storms, when rainfall is often heavy, was found to be essential.

With the transfer of the Fairbanks station and the closing of the Kodiak station, the work carried on will be centered at Matanuska and Sitka. The work at the Matanuska station is largely in agronomy, horticulture, livestock breeding and management, and dairying. Some attention is given to cooperative marketing and land settlement. The region in which this station is located is intermediate in climate between the dry interior and the wet coast region, and is believed capable of considerable agricultural development.

Plant breeding and variety tests to establish varieties of cereals, root crops, and vegetables that can be de-

pended upon to grow in this region, were continued.

The hardiness of the Galloway-Holstein crosses made by the station has been demonstrated, and the experiment is being continued to fix the type so that breeding stock will be available to settlers.

The work at the Sitka station is carried on primarily for the benefit of southeastern Alaska where topography and climate make grain growing and extensive agriculture impracticable. Vegetable and small-fruit experiments have resulted in the establishment of varieties suited to the region. Some attention is given to ornamentals, as home makers have shown a very lively interest in making their homes more attractive.

E. A. Eggersgluess, assistant horticulturist at the Sitka station, died March 27, 1931, and was succeeded by Clifford Cordy.

Hawaii station.—The past year, the second under the plan of coordinating the work of the Federal experiment station with that of the University of Hawaii, was characterized by substantial progress. Under the consolidation plan a wider scope of research has been possible and an increased interest in the station's work has been manifested. A new substation was established in the Kona district of the island of Hawaii, and experiments with coffee, tropical fruits, and nut trees were begun. On the island of Maui, in addition to the substation at Makawao at an elevation of 2,100 feet, tracts have been set aside by executive order or secured through cooperative agreements that will make possible experimental work with various crops up to an elevation of 6,400 feet. If these experiments are successful, more than 20,000 acres of waste land on Maui alone can be made productive. The work at Makawao has already extended the planting of pineapples 1,000 feet higher than was previously thought practicable.

Experiments with pigeon peas, grasses, and other forage plants were extended during the year. A planting of nearly 1,000 varieties, hybrids, and selections of pigeon peas was made for comparative studies. More than 50 species of grasses are under test and some have shown such promise that large plantings have been made to supply requests for propagating material.

The Macadamia-nut investigations have progressed to a point where much interest has been aroused in the possibility of growing the nuts on a commercial scale. In addition to plantings on the various islands, more than 200 acres have been planted recently in the Kona district of the island of Hawaii. The oil content of the nuts has been found to vary widely, and the information obtained is being used in further selection and breeding work.

Further studies of edible-canna starch have shown that it most nearly resembles potato starch, but that there are some important differences that adapt canna starch to special uses. The native raspberry, or akala berry, has been secured from the high mountains of Hawaii and planted on the higher portion of the main station grounds. Breeding experiments to develop commercial forms of this berry for domestic plantings have been begun.

Experiments in feeding cane molasses to dairy cows, that have been in progress for several years, indicated that somewhat less than 25 per cent of the carbohydrate of the ration can come from cane molasses.

Experiments on the control of sorehead, or fowl pox, of chickens, have shown that mosquitoes are an important factor in spreading the disease among young chicks. The advantages of rearing chicks in confined quarters in Hawaii have been satisfactorily demonstrated on an extensive scale.

Recent studies of locally produced food products, such as Chinese cabbage, oranges, rice, etc., have shown their vitamin content to equal those of similar products grown elsewhere.

Puerto Rico station.—George F. Freeman, who succeeded D. W. May as director of the station at the latter's retirement on April 22, 1930, after 26 years' service, died September 17, 1930. He was succeeded as director by T. B. McClelland, who for more than 20 years had been in charge of the horticultural work of the station.

On March 4, 1931, Congress extended the Hatch, Adams, and Purnell Acts in modified form to Puerto Rico, and the first appropriation is authorized for the fiscal year 1933. The act provides that the experiment station to be established shall be connected with the College of Agriculture of the University of Puerto Rico and that it shall be conducted jointly and in collaboration with the existing Federal experiment station in Puerto Rico in enlarging and expanding the work of the Federal station on cooperative plans approved by the Secretary of Agriculture. The Secretary of Agriculture is also authorized to coordinate the work of the Territorial stations

with that of the Federal station and of the United States Department of Agriculture in the island. It is further provided that the experiment stations now conducted by the insular government shall be transferred to and coordinated with the experiment station of the College of Agriculture. Preliminary negotiations to effect the results implied by the legislation have been begun.

The work of the station in some lines was retarded during the year by changes in the directorship and by failure to fill several vacancies.

The breeding work with sugarcane and corn was continued. Several cane hybrids made at the station are practically free from mosaic or are not affected to an extent of commercial importance, and they have excellent agronomic and milling characteristics. About 600 acres of these seedling canes, planted cooperatively, will be available for harvest in the near future. Some of the new varieties are exceedingly promising. The corn-breeding work, much of which is carried on in cooperation with planters, is yielding good results. One station selection yielded in 1930 at the rate of 57.8 bushels per acre, a high yield for Puerto Rico. A large number of additional cane and corn hybrids and selections are under test.

In cooperation with citrus and pineapple growers, studies were continued on the root growth of citrus varieties as related to stocks and soils and on methods for controlling the time of blooming of pineapples. Important data on the value of certain types of rootstocks for budding and as related to cultivation and fertilization have been secured. Neither root pruning nor applications of calcium phosphate influenced the time of blooming and fruiting of pineapples.

In investigations on the bay-oil industry a simple method for rapidly determining the types of trees that produce the undesirable lemon-scented leaves was worked out.

An extensive series of fertilizer experiments with coconuts was concluded and the results published. Data on the yield of nearly 500 individual coconut palms over a period of more than eight years showed wide inherent variation in production of individual trees. This fact is considered important in future work in improving coconut production.

Important information on some of the parasites of livestock was secured during the year. An intermediate host of the thornheaded worm of swine was found to be a water beetle. Studies of the liver fluke that infests calves appear to indicate that under local conditions the encysted stage of the parasite which is found attached to grass is resistant to drought and may remain infective for several months.

Guam station.—Considering the limited personnel and income of the station, commendable progress was made during the year.

Through the cooperation of the Bureaus of Animal Industry and Dairy Industry, and of the Navy Department in furnishing transportation, valuable additions to the station herds and flocks were made. The station now has creditable herds of Ayrshire cattle and Duroc-Jersey hogs, and flocks of Rhode Island Red and White Leghorn chickens. Increased use of the station's sires in breeding up the native stock is reported.

The work with poultry is attracting much attention among the people and during the year more than 800 dozen eggs were supplied for hatching.

In further experiments with forage plants, Napier and Guatemala grasses proved to be more widely adapted to Guam conditions and more readily eaten by stock than Japanese cane. Tests of a large number of leguminous plants as cover crops and as food for man and stock were continued. A variety of mung bean recently introduced appears to be very promising.

The horticultural work of the year consisted mainly in maintaining and extending the collections in order to determine the varieties best adapted to Guam conditions, investigating methods of propagating tropical fruits, testing citrus stocks for resistance to gummosis, and experiments with vegetables. The Marglobe tomato, Charleston Wakefield cabbage, White Cornfield string bean, and Henderson Bush Lima bean are proving to be among the best of their respective classes for growing in Guam.

On account of the low price of copra, the most important crop of the island, the station has endeavored to find other cash crops for export. Successful trial shipments of avocados to Manila indicated the possibility of developing a limited market for good varieties of this and other fruits. Experiments with special crops that are sources of drugs and insecticides were begun with a view to exporting the products to the United States.

Work on parasites of the corn borer, introduced through the cooperation of the Bureau of Entomology of the Department of Agriculture, was contin-

ued. The fly situation was improved by establishing a parasite of stable flies and house flies, *Spalangia* sp., in a number of localities. The coconut-scale situation continued favorable, a biological balance apparently having been established between the scale and its parasitic and predatory enemies.

Virgin Islands station.—J. B. Thompson, for nearly 10 years director of the station, was transferred to work being carried on by the Bureaus of Plant Industry and Animal Industry at Jeanerette, La., and was succeeded March 1, 1931, by J. R. Ricks, formerly director of the Mississippi experiment station. M. S. Baker, agronomist of the station for about six years, resigned in November, 1930, to go to a large sugar plantation in Puerto Rico. Helen L. Cawley was appointed home demonstration agent April 1 and N. N. Nichols was appointed associate animal husbandman and dairyman May 1. D. S. Blackwood was appointed farm superintendent July 1, and Glen Briggs, formerly of the Guam and Oklahoma stations, was appointed agronomist October 24, 1931.

Economic conditions in the Virgin Islands had been unsatisfactory for some time, and following a prolonged drought in 1929 the sugar crop was so reduced that all sugar mills on St. Croix except one were closed and the plantations ceased operations. This caused serious economic disturbance and much unemployment. The situation was so serious that at the suggestion of local authorities and of the Chief of the Bureau of Efficiency, who made a survey of the Virgin Islands in 1930 at the request of a congressional committee, the station suspended some of its usual activities and devoted its energies to encouraging the people to plant and cultivate gardens as a relief measure. Several hundred gardens were planted and tended by persons out of employment, and the vegetables so produced aided materially in relieving the distress.

Following the survey made by the Chief of the Bureau of Efficiency, a civilian government was substituted for the naval government which had been in charge of the islands since they were acquired in 1917. Appropriations were made by Congress for the temporary government of the islands, and an allotment of $16,700 was made for expanding the work of the station in the fiscal year 1931. This increase in the income of the station made it possible to appoint a home demonstration agent and a dairyman and also to provide for several special investigations. It also made possible some badly needed improvements of station property and additions to equipment. Projects in home demonstration work and in dairying were set up and made considerable progress.

For a number of years the production of sea-island cotton was profitable in St. Croix, but the advent of the pink bollworm and the low price of cotton resulted in its abandonment. In order to determine whether the industry could be restored, U. C. Loftin, of the Bureau of Entomology, made a survey of the situation and, based on his findings, a campaign for the destruction of wild host plants of the pink bollworm was begun. It is hoped that this, together with a closed season in which all cotton plants are destroyed, will result in reestablishing the growing of cotton, a crop that seems especially well adapted to small holdings.

Activities designed to restore former agricultural industries included a survey of the bay-oil industry by W. W. Skinner, of the Bureau of Chemistry and Soils, and plans for investigations designed to improve bay-oil production, an industry in which the Virgin Islands formerly led, were considered.

A reconnaissance soil survey of St. Croix was made by J. T. Thorp, of the Bureau of Chemistry and Soils, and the principal soil types were outlined and described in order to provide a basis for better adaptation of crops to soils in the islands.

Special attention is being given to studies of rootstocks for orange and grapefruit trees adapted to the principal soil types. Experiments in the control of chlorosis of grapes and pineapples, a disease that makes the growing of these crops very precarious in the islands, are in progress.

The veterinarian and animal husbandman continued efforts to improve the livestock of the islands and to prevent disease losses. Through the cooperation of the Bureau of Animal Industry improved horses, cattle, swine, goats, and sheep were secured by the station and made available for breeding up local herds and flocks. The veterinarian also acted as quarantine officer for all livestock introduced into, or shipped from, the islands. In addition he did much service work on diseases.

The extension and demonstration work on the islands of St. Thomas and St. John progressed as formerly.

The extension agent continued to seek new and improved varieties of fruits and vegetables, profitable methods of marketing crops, and new uses for surplus products. The native soursop, a common fruit, was successfully canned, and samples of the canned product sent to New York and other markets were favorably received.

The work of the home demonstration agent included studies of food and nutrition, school lunches, women's clubs, 4–H clubs, and the improvement of village groups.

WALTER H. EVANS.

SOME RESULTS OF STATION WORK

The work of the experiment stations covers a wide range and variety of subjects, as is shown by the 7,000 or more research projects in which the stations are engaged and by the approximately 1,000 reports, bulletins, and circulars and the 1,700 articles in scientific and technical journals annually published by them. From this large volume of published work specialists of the Office of Experiment Stations have selected for the following reviews a limited amount of such material as in their judgment is fairly representative of the services the stations are rendering in solving some of the many important agricultural problems to which they are giving attention.

SOILS AND FERTILIZERS

The general character of experiment station work on soils and fertilizers during the past year did not differ greatly from that of previous years, but there was distinct advance in the work as a whole. The following examples from among many that might be mentioned illustrate the kind of work done and show some of the conclusions reached.

The cause and prevention of soil erosion and run-off are receiving increasing attention from the experiment stations, which in many cases are cooperating with the United States Department of Agriculture, with results that indicate ways of reducing the enormous losses from these causes. Investigations carried on by the Missouri station for many years have shown that erosion is about seven times as great from soils continuously cropped with corn as from those under a good rotation and nearly fifty times as great as from grass sod. Deep plowing (8 inches) reduced erosion to some extent. The Texas station, among others, has demonstrated the value of terracing, not only to prevent erosion but to conserve water in regions or seasons of scanty rainfall, and has tested and improved methods of terracing for these purposes.

The conditions necessary to effective leaching of alkali from soils were studied by the Utah station where it was shown that this is an exceedingly slow process requiring many years for completion.

Soil colloids in relation to tillage and other methods of soil culture and management continued as a major subject of investigation by a number of stations. During the year the California, Hawaii, New Jersey, and New York (Cornell) stations reported results having an important practical bearing on improvement of tilth and tillage implements, retention and movement of water in the soil, and response of soils to fertilizers and other treatment. (See also p. 19.)

The value of water-covered soils not only in relation to fish culture, wild fowl, and aquatic fur-bearing animals, but for production of plants directly useful to man, was indicated in a study and classification of such soils by the Michigan station.

That superphosphate applied on or near the surface of the soil is not utilized to the best advantage by crops (pasture grasses), because of its very slow penetration of soils, is an important practical finding of the Vermont station, indicating the advantage of more thorough incorporation of the superphosphate with the soil. The California station found that there was greater penetration of superphosphate into the soil when it was applied with manure.

Further progress in showing how green manures and fertilizer salts may be substituted for manure in the production of market-garden crops was reported by the Rhode Island station. This is a matter of much practical importance in view of the diminished supply of manure. As a result of such work as that of the Rhode Island station, market gardeners, tobacco growers, and others find it possible to adjust their farming operations to the limited supply of manure with very satisfactory results. The New Jersey stations have shown that to a certain extent peat may be substituted for manure.

That muck soils may contain relatively large amounts of nitrates and therefore may not need, and in fact

may be injured by, the large applications of nitrogen fertilizers often made to such soils, is a finding reported by the New York (Cornell) station.

Liming and application of sodium nitrate greatly increased nitrogen fixation in soils, in experiments reported by the Ohio station. Applications of potassium chloride and superphosphate were less effective in increasing fixation. Nitrogen-fixation organisms were not found in even moderately acid soils.

The above and other important examples of recent work of the stations on soils and fertilizers are reviewed in more detail in the following pages.

Exhausted soils.—On a series of long-period fertility plats in different parts of the State, the New Hampshire station continued to secure information useful in planning methods of improving worn-out soils. Results recorded at five places in the State where this work is being done indicate distinct differences in the local limiting factors and therefore in the means that must be employed to restore these soils.

Eroded soils.—By heavy applications of lime and fertilizer, the Missouri station raised the nitrogen content of artificially exposed subsoils to about three-fourths that of corresponding surface soils and secured fair yields of wheat on the treated subsoils.

Acid and toxic soils.—Investigations on soil acidity and aluminum toxicity as factors in low soil productivity were continued by a number of the stations. Active aluminum in the soil was shown by the Rhode Island station to have an inhibiting effect greater than that of soil acidity upon the growth of lettuce and barley plants. In solution cultures ranging from very acid (pH 3.2) to slightly alkaline (pH 7.5) lettuce seedlings produced essentially the same dry-weight yields, but when aluminum sulphate was added to the solutions the yields were markedly depressed.

That a given degree of acidity is not necessarily in itself a direct cause of poor plant growth was indicated in experiments by the Alabama station, in which it was found that the critical hydrogen-ion concentration (acidity) for the growth of crops differed in different soils.

Applications of superphosphate tended to reduce the acidity of the soil in experiments reported by the Kansas station. After a few months, however, the soil thus treated was found to have reverted to its original reaction.

Alkali soils and "slick spots."—In a study of the relation of permeability to the sodium content of the soil, the Utah station found in laboratory experiments that the permeability decreased with increasing sodium content. In the absence of alkali an increase of humus in the soil increased permeability, but in sodium-saturated soils the reverse was true. These experiments yielded data for calculating the time required to leach out any definite proportion of the exchangeable sodium under stated conditions. For example, with a leaching water containing about 35 parts per million of calcium, a surface layer of soil was calculated to require 18.8 years for the reduction of the replaceable sodium from 88 per cent of saturation to 10 per cent. The calcium carbonate or calcareous layer could be similarly improved, according to a like estimate, in 15.6 years. Under field conditions the rate may be a little more rapid than these laboratory figures indicate.

Slick spots were investigated by the Idaho station with particular reference to the effect of their constituents on texture and crop growth. The Nevada station reported investigations indicating that the lack of improvement in plant growth when slick spots are treated with fertilizers may be caused less by toxic substances in the soil than by starvation caused by fixation of plant food in unavailable forms.

Physical properties and behavior of soils.—The need of more scientific management of soils, based upon a knowledge of soil properties and behavior, is emphasized by the work of many of the experiment stations. Research along this line was continued and strengthened during the year. Such studies ranged from work on tilth to fundamental studies of soil colloids. Naturally, investigations of this kind are in large part highly technical, and a detailed statement of conclusions from them would be out of place here. It is sufficient to indicate that the results obtained are fundamental to progress in practical mastery of soil management and to show that the stations are strengthening research of this kind.

Recognition of the practical importance of soil colloids and the part they play in the physical and chemical properties and behavior of soils is indicated by the large volume of station work which has been done and is now in progress. The New Jersey stations have published six papers recording results of a series of investigations dealing with the nature of soil colloids and the laws governing their behavior. The New York (Cornell) sta-

tion reported a study of soil properties by the flow-plasticity method. The Hawaii station reported upon the colloid fraction of the peculiarly developed Hawaiian soils and on capillary phenomena, which play an important part in the movement, retention, and availability to plants of the moisture supply of soils. Similar contributions came from other stations.

In a study of soil factors affecting tilth (see also p. 90), the Kansas station found that the coefficient of friction between soil and a metal surface increased with increasing moisture content and that liming acid soils decreased the coefficient of friction by from 10 to 20 per cent. The coefficient of friction increased with the fineness of the granulation of the soil, and this could be modified by liming and other treatments.

In soil-moisture studies the Kentucky station found that in a clay loam subsoil under a silt loam surface soil in which crops suffered from lack of water, there was a considerable quantity of water which the plants could not get.

By drying soils or exposing them to ultra-violet light, the Kansas station increased their water-soluble content. There was a marked increase in the rate of settling of the colloidal part of soils treated with ultra-violet light. The treatment also reduced slightly the number of bacteria in the soil. It was concluded that the ultra-violet content of sunlight may have a slight effect upon the properties of field soils.

Mechanical analysis and classification of soils received the attention of several stations. The Ohio station reported a study of size frequency of soil particles; the New Jersey stations, an analysis of available data on soil profiles; and the Michigan station, a classification of water-covered soils. The hitherto unclassified and little used water-covered soils of Michigan were shown by the station to be of value not only in their relation to fish culture, wild fowl, and aquatic fur bearers, but also for the production of useful plants.

Mineral nutrients.—The farmers of the United States expend annually about $230,000,000 for commercial fertilizers. The object of this expenditure is more economical crop production. For the best results there must be reliable information on the fertilizer elements needed by the various soils and crops, the amount and chemical form in which they will be most effective, the best methods of applying them, and the changes they undergo in different kinds of soils. This can be obtained only through scientific investigation, much of which is very technical. The work on the complex soil reaction known as base exchange, in which a number of stations are engaged, is typical of this kind of investigation.

A practical application of base-exchange data in the form of a roughly quantitative estimation of water-soluble and exchangeable soil potassium has been proposed by the Illinois station. The test may well prove a simple and reliable means of determining the potash needs of soils.

Organic matter plays an important part in base exchange in soils according to the Vermont station, which suggests that any system of farming tending to increase the organic-matter content should increase also the quantity of the more or less unknown substances acting as the base-exchange complex.

Absorption of potassium by plants was found by the Arkansas station to occur at such a rate that there is not likely to be any residual effect from potassium fertilizers where crops are removed from the soil. Rapid absorption of potassium in the earlier stages of plant growth appeared, in these experiments, to deplete the soil supply so far that only by translocation and reutilization of potassium already taken up could the plants maintain good growth during later stages of development. Other work on potassium needs includes the observation by the Florida station that liming a sandy soil may result in plant starvation, which can be corrected only by applying potassium salts or by increasing the biological activity of the soil.

Means of ascertaining phosphate needs were studied by the Indiana station, among others, with the result that while the Neubauer method, based on the determination of the phosphates taken up by seedling plants, did not correlate well with the most commonly used chemical methods, it gave results agreeing sufficiently well with those of pot tests to make the method a source of valuable information as to the true availability of various phosphates.

In a study of the behavior of superphosphates after being applied to the soil, the Vermont station found that when applied as a surface dressing they remained mostly within the surface inch even after an interval of several months. The best results, it was shown, could not be expected unless the phosphate was well mixed with the soil. Superphosphate worked

into an established grass sod gave an increase 71 per cent greater than that from a similar application left on the surface. The results obtained by the California station also confirm the slow penetration of phosphates, 22 annual applications having given no evidence of penetration below the first 12 inches. Phosphates contained in or applied with manure, however, showed a more rapid penetration of the soil by the phosphates, an effect considered possibly attributable to organic matter.

The effects on soil-phosphate availability of several soil molds and bacteria were studied by the Iowa station, and it was found that some of these organisms were able to dissolve more phosphate than they absorb, while others took up more than they brought into solution. This, of course, would lessen for the time at least, the supply available to crop plants.

Quality of mixed fertilizers.—In view of the waste involved in transporting inert constituents of fertilizers, the observation of the Vermont station, that 96 per cent of the brands of fertilizer licensed in Vermont contained 14 per cent or more of actual plant food, is of interest. The average "high analysis" goods (14 per cent or better) contained 60 per cent more plant food than did the "low analysis" material, and cost much less per unit of plant food. Improvement in commercial fertilizers was noted also by the Rhode Island station, where 93 per cent of the materials analyzed met guarantees fully and only 3 per cent failed by as much as 0.3 per cent.

Organic matter and nitrogen.—In experiments to determine the practicability of replacing manure with green manures and commercial fertilizers for market-garden crops, the Rhode Island station found that green manures combined with fertilizer chemicals produced about 25 per cent more high-grade early tomatoes than were obtained from the use of stable manure. Certain of the crops of a 3-year rotation did as well with an application of 16 tons of stable manure where a green manure had been plowed under as with 32 tons of stable manure without the green organic matter, and in another rotation 8 tons of manure compost in addition to a green-manure crop gave better results than did 20 tons of the compost without the green manure.

In a study of peat as a substitute for manure, the New Jersey stations found cultivated New Jersey peat and raw Michigan peat the most effective among five sources of organic matter for this purpose. The organic matter of manure was more rapidly decomposed and lost than was that provided by any other source of organic matter tested. The organic matter of cultivated peat and of mushroom soil was more permanent than that provided by raw peat or by peat moss. Other types of organic matter, it was concluded, can satisfactorily be substituted for stable manure if nutrient deficiencies are met by additions of fertilizers.

In a study of certain organic soils the New York (Cornell) station found that the biological decomposition of organic matter characteristic of such soils did not inhibit the presence of large quantities of nitrates in the soil. It was concluded that the extent of these nitrate accumulations may be such as to render the large applications of nitrogen often used on muck soils excessive and even injurious to certain crops, especially on newly cleared mucks.

Three times as much nitrogen was removed from the soil by crops in an alfalfa rotation as in a timothy rotation, in experiments reported by the New York State station. Further, the drainage water from the leguminous rotation contained 2.5 times as much nitrogen as that from the nonleguminous rotation, indicating the great importance of so cropping the soil as to make use of this available nitrogen, which might otherwise be lost.

Soybeans used as a green-manure crop by the Missouri station showed so great an increase in the ratio of carbon to nitrogen as the plants approached maturity that it appeared that the decomposition of this material in the soil might absorb for the time the soil nitrogen required by other crops. The Ohio station found a carbon-to-nitrogen ratio greater than 10 to 1 to be unfavorable to nitrate accumulation in soils. Lowering this ratio led to an increased formation of nitrates. A ratio of 15 to 1 favored nitrogen fixation.

In a study of the organic-matter content of surface soils from regions of widely different temperature, the Missouri station found that the organic matter decreased with increasing temperature; that is, the organic-matter content of soils of warmer regions was lower than that of soils of colder regions. A more or less definite mathematical relation could be shown.

In experiments at the New Jersey stations from 25 to 45 per cent of the nitrogen of nitrogenous fertilizers ap-

plied with manure was recoverable in the crop. Excessive applications of nitrogen were generally accompanied by heavy loss and a correspondingly decreased recovery in the crop.

Soil microbiology.—In a study of ammonification by various soil microorganisms, the Utah station found that protein substances and related sources or organic nitrogen were more or less readily nitrified by certain of the organisms, but that calcium cyanamid among other substances was not ammonified by any of them.

Of the two root-nodule organisms *Rhizobium leguminosarum* and *R. trifolii*, the New York (Cornell) station found the latter to be more abundant. The differences in the capacity of the soil to support these two species did not appear to depend upon reaction or moisture content, but upon the nature of the salts present. Sulphur applied at the rate of from 50 to 200 pounds per acre reduced the number of both organisms.

The number of nitrogen-fixing organisms (Azotobacter) was found by the Ohio station to be greater in limed soils than in soils which had been both limed and treated with fertilizers. The growth of Azotobacter was greater after treatment of the soil with sodium nitrate than after additions of either potassium chloride or superphosphate. Azotobacter was not found in soils more acid than pH 6.

Methods and technic.—The development of improved technic and methods becomes increasingly important as the research in soils and fertilizers grows more complex. Frequently conventional methods fail to meet the needs of more advanced research. The experiment stations are therefore, of necessity, making important contributions to the methodology of research. A few of the more recent of these are noted below.

Improved methods of sampling field soils have been reported recently by the New York (Cornell), Rhode Island, and Ohio stations. A simple and rapid bacteriological method of determining the fertilizer requirements of soils has been perfected by the Colorado station. A colorimetric method for determining phosphoric acid in soils has been reported by the California station; a field method for determining lime requirements based on base-exchange relations, by the Illinois station; an electrical method for determining moisture in soils in place, by the Texas station; an improved soil-sampling tube, by the Oklahoma station; a method of injecting solutions of fertilizer salts into the soil, by the California station; a test for water-soluble and exchangeable potash in soils, by the California station; a simple field test for available phosphoric acid, by the Wisconsin station; a method of correlating nitrate concentration in the leaf juices with the nitrate content of the soil, by the Rhode Island station; a method for determining organic matter in soils, by the Ohio station; a method of measuring the degree of saturation of soils with bases, by the Iowa station; a procedure for comparing rates of percolation through soils, by the Michigan station; a method for determining the relation of pH drift to the moisture and base content of soils, by the Kansas station and others; and methods of determining the volume weight of soils, by the New Mexico station.

HENRY C. WATERMAN.

FIELD CROPS

Research by the experiment stations in the many phases of crop production continued to evolve superior varieties of grain and forage and root crops, more effective cultural methods and field practices, more exact information on the plant-food needs of crops and methods of supplying them, productive crop rotations, and improved ways to control weeds. The following examples of results reported during the year are of special significance over large areas.

Farm practices returning higher yields per acre at reasonable costs enable farmers to make their usual crops on fewer acres of their best land and release the less desirable areas for pasture and other uses. Early seed-bed preparation for winter wheat, a practice reducing volunteer grain and weed growth, was found by several stations to increase wheat yields. By early tillage to control weeds after harvest, the Nebraska station working with the Department of Agriculture increased the 10-year average yield of winter wheat more than 30 per cent and the yields of barley, oats, and corn about 25 per cent. The merits of early preparation for wheat were also demonstrated by the Kansas, Ohio, Oklahoma, Oregon, and Texas stations.

Pasturage, a major factor in economical livestock production, furnishes at a low cost practically half of the total feed consumed by livestock in the United States. Pasture provides a profitable way to utilize land not suitable for economical cultivation.

Pasture lands formerly were given but little attention and their production declined. The increasing numbers of sheep and dairy cows and other cattle on farms call for larger and more productive pastures. The pasture improvement work of the stations, involving controlled grazing, renovation, reseeding, and fertilization, has aroused widespread interest.

Deferred and rotation pastures were found by the Kansas, Oklahoma, Colorado, and Western Washington stations to be superior in quality, condition, and beef production to pastures grazed continuously. The capacity of native blue-stem pastures at the Kansas station under deferred and rotation grazing averaged for 11 years 30 per cent higher, the gain in weight of stock 20 per cent greater, and the quality and quantity of forage better than in pastures grazed season long. Expressed as animal-days per acre, the amount of feed was 50.5 for the rotation system and 32.9 for continuous pasture. Pastures responded profitably to fertilizers in experiments by the Massachusetts, New Hampshire, Virginia, and Wisconsin stations.

Alfalfa hay, which makes up about 30 per cent of the total tonnage of tame hay grown in the United States, provides a good example of the importance of quality in products. For maximum feed value and the highest market price, alfalfa hay should be pure and free from mustiness and mold and should possess a high percentage of leaves, clinging foliage, green color, and pliable stems. Practical plans for curing alfalfa hay, according to Nebraska station experiments made in cooperation with the Department of Agriculture, should aim toward conserving the leaves, which contain nearly three-fourths of the protein, and avoiding rain damage. Practices that shorten the interval between cutting and storage and yet are conducive to good quality included leaving the hay for a suitable period in the swath before windrowing it, making small windrows, turning windrows within four hours after raking, and turning or scattering partly cured windrows or cocks wet from rain. Cocking as a part of curing was found inadvisable under Nebraska conditions.

Mechanical injury, a factor lowering the quality of potatoes, causes losses in preparing potatoes for the table and increases shrinkage, rot, and other losses. In Nebraska alone, the potatoes damaged too much for shipment as United States No. 1 grade were estimated to amount to 2,380 cars in 1928 and 1,820 cars in 1930, and the money loss, to western Nebraska potatoes, to at least $200,000 a year. Such injury, Nebraska station experiments showed, could largely be avoided by proper methods of handling and proper equipment and storage. Practical recommendations included reasonable maturity, a moderate soil-moisture content where this factor can be controlled, care in the selection and adjustment of the digger, allowing potatoes to dry after digging, lining the picking baskets, care in handling, and proper storage conditions.

Methods of fertilizing potatoes have changed markedly in recent years as a result of experiments by the stations and other agencies. Potato growers are tending to use larger quantities of fertilizer, more inorganic nitrogen, and lately, concentrated fertilizer mixtures—changes resulting in more economical use of fertilizers and, in general, in lower production costs. Significant effects of fertilizers on the cooking quality of potatoes also have been reported. The earlier work dealt largely with yields, whereas a recent study of the New Jersey stations and the Department of Agriculture dealt with the influence of fertilizer elements on the shape, size, and number of potatoes. Nitrogen appeared important in determining the size of tubers, and the quantity of potassium present was chiefly responsible for modification of the shape. Fertilizers containing both nitrogen and potassium produced relatively high yields and those deficient in either or both elements produced low yields.

The enormous quantities of fertilizer used for the cotton crop of the United States, in several recent years exceeding 2,400,000 tons, valued at nearly $76,000,000, and the importance of fertilizer in the economy of cotton production have furnished incentives for extensive station research on fertilizer mixtures, sources of materials, and methods of application, largely directed toward higher yields, earlier maturity, and reduced costs of production. In studies of the most effective ways to apply fertilizer to cotton mechanically the South Carolina station, cooperating with the Department of Agriculture and other agencies, obtained greatest yields with the fertilizer placed closest to the seed, when injury to germination was not serious. Applications in bands on each side of the seed gave best yields on lighter-textured soils, and applications in narrow bands below the seed were best on sandy clay loam.

Other examples of research with field crops are reviewed further, in the pages which follow.

CROP IMPROVEMENT

Many improved varieties and selections of field crops, developed at the stations either independently or in cooperation with the Department of Agriculture, have recently been distributed to farmers because of their proven productiveness, earliness, disease resistance, adaptation to peculiar environmental conditions, or commercial value. That the merits of such varieties are recognized was shown by surveys which indicated that more than 55 per cent of the Iowa oats acreage was planted with varieties originated at the Iowa station, and that Iobred wheat made up about 20 per cent of the wheat acreage and Ioturk wheat nearly 5 per cent. At least 10 per cent of the State's current corn acreage was planted with high-yielding strains discovered through yield tests. The Virginia station estimated that from 25 to 50 per cent of the wheat grown in its State was either V. P. I. 131 or the beardless V. P. I. 112, its high-yielding selections from Fulcaster and Poole wheats, respectively.

Other productive wheats comprised Gasta, a Georgia station selection from Purplestraw, resistant to strains of loose smut; Cheyenne, a Nebraska station selection from Crimean, with erect culms and heads, stiff straw, and resistant to shattering; Komar, a spring wheat produced from Marquis × Kota by the North Dakota station, resistant to stem rust; Progress, a spring wheat of the Wisconsin station, highly resistant to Fusarium scab and rather resistant to black stem rust; and Poso, an early club wheat, derived from Little Club × Clarendon by the California station. Tenmarq, a hard red winter wheat produced by the Kansas station from Marquis × a Crimean selection, has earliness, excellent quality and stiff straw, and Kawvale, a Kansas station selection from Indiana Swamp (Valley) is highly resistant to leaf rust and somewhat so to Hessian fly.

New high-yielding oats varieties found good enough to release included Columbia, an early, stiff-strawed selection from Fulghum by the Missouri station; Colorado 37, a stiff-strawed oats resembling Swedish Select, by the Colorado station; Rainbow, selected from Green Russian by the North Dakota station, with a stiff straw and resistance to stem rust; and three productions of the Ohio station—Franklin, selected from Fulghum, Miami from Siberian, and Wayne from a hybrid.

Among the promising barleys were Colsess, a hooded, high-altitude variety of the Colorado station; Union Beardless, a productive Oregon station barley good for grain, hay, or silage; Spartan, an early, high-yielding, stiff-strawed, smooth-awned Michigan station barley developed from a hybrid, and Pedigree 38, a Wisconsin station barley, productive, smooth awned, stiff strawed, and disease resistant.

Additional evidence of advances in crop improvement is furnished by the Michigan station finding that crossing local Michigan corn varieties with the resistant Maize Amargo will produce strains of corn resistant to attack by the European corn borer; by the anthracnose-resistant red clover selected by the Tennessee station; by Hardistan, a vigorous alfalfa relatively resistant to bacterial wilt, discovered by the Nebraska station; by the cotton strains brought forward by the stations in the Southern States—Arkansas Rowden 40 of the Arkansas station is a good example—and by the many superior selections and strains of legumes and grasses.

CULTURAL PRACTICES

Production of high yields of farm crops per acre at costs returning a profit to the farmer calls for efficient cultural methods and field practices. To help the farmers solve such problems, the station agronomists continued to seek the best methods of preparing the land, the best seed treatments, and the best conditions for planting, cultivation, harvesting, and storage.

Cereals.—Farm practices that lower the cost of growing wheat, the Oklahoma Panhandle station found, include crop rotations leaving the least quantities of organic residues in the soil, summer fallowing only in extreme cases, vigorous weed control during preparation of the land, deep tillage once in every two to four years, applying farm manures to hay crops in rotation with wheat but never directly on the wheat, terracing to conserve run-off water for crop production, and planting productive, adapted varieties.

The value of preparing the seed bed early for winter wheat was demonstrated by several stations. Early

seed-bed preparation for winter wheat to reduce volunteer grain and weeds was found by the Nebraska station to be an important factor in high yields. Early tillage at North Platte to control weeds after harvest increased the 10-year average yield of winter wheat more than 30 per cent and of barley, oats, and corn about 25 per cent. Plowing was slightly better than listing or disking in preparing the seed bed for winter wheat in Texas station experiments at Chillicothe. This station, too, observed that whatever method be used, preparation should be as early as possible, at least by July 31. The Ohio station found early plowing, August 1 to 15, without further treatment until planting, to be the best method of preparing oats stubble for wheat.

Seed-bed preparation experiments on continuously cropped dry land, made by the Kansas station cooperating with the Department of Agriculture, favored early cultivation before planting, for weed control and conservation of moisture. The best method of fallow for wheat included fall listing or fall plowing followed by clean cultivation the next summer.

Winter wheat grown after fallow by the Oregon station in cooperation with the Department of Agriculture averaged higher in yield on April and May plowing than on fall or later spring plowings, and fallow plowed 5 inches deep returned nearly as much as did 10-inch plowing. Wheat yields on fallow suggested that disking might be substituted for plowing on many of the lighter soils of the Columbia Basin.

In comparing methods of handling grain straw, the Oklahoma station determined that the highest wheat yields followed early plowing where straw had been burned, and the next highest yields followed plowing the straw under early. The moisture conserved by treatments after wheat harvest indicated that stubble should be disked just after harvest, even though no weeds or grass were present.

Lodging in oats and wheat caused by factors other than mechanical impact, the Ohio station found, could partly be controlled through the seed used and through handling the soil. Plants from the lighter-seeding rates, the larger seed, or stiff-strawed varieties usually tillering sparingly were not so inclined to lodge. The most helpful soil practices were those tending to reduce temporarily the available fertility, particularly the nitrates, as with a straw mulch. A rotation in which gross feeders, as corn and soybeans, came before small grain was preferred to a rotation in which a legume like alfalfa predominated. Plowing rather than disking or no seed-bed preparation often resulted in increased soil nitrates and more stems per acre and often made the difference between lodging and not lodging.

The straw of soft wheats found resistant to lodging by the Kansas station usually was harder to break than that of hard wheats lodging easily. Varieties intermediate in tendency to lodge were intermediate also in breaking strength of straw.

The principal effect of cultivating corn, the Nebraska station observed, was preventing weed growth. Wide latitude evidently can be allowed as to shallow, close, or wide cultivation, provided weeds are destroyed equally well. Likewise in Texas station experiments, cultivation chiefly for controlling weeds and enough to control weeds was the most practical cultivation for corn and other crops. Medium-deep cultivation for corn until tasseling and laying by deeply when the corn was waist high were found by the Arkansas station to be superior to other cultivation methods.

For best results seed corn should not be picked until it is mature, or at least fully dented, according to the Illinois station; however, it should be gathered and placed in a suitable drying room before it is endangered by killing frosts.

The best seeding time for maximum grain yields from grain sorghums differed with variety and locality in Texas station studies. For highest grain yields varieties tillering freely needed more space than those tillering slightly. For example the milos, freely tillering and grown primarily for grain, should be spaced from 12 to 24 inches; kafir, tillering sparsely, around 6 inches; and hegari and feterita, freely tillering but important forage types, 6 to 12 inches.

Cotton.—Cotton on late-prepared fine sandy loam at Lubbock, the Texas station found, slightly outyielded that on land prepared in fall or winter. Plowing 7 inches deep proved better than plowing 3.5 inches deep or listing deep or shallow. At Chillicothe, however, time and method of preparation were not related consistently with yield, provided the soil was stirred thoroughly about 5 inches deep before weed growth started in the spring.

The daily mean temperatures of the air were found by the Arizona station to be fairly close to those of the soil at cotton seed-bed depths at planting

time. Indications were that cotton probably should not be planted until mean temperatures approximate 60° F. or higher. The best stands and yields came from planting by some method insuring close contact between the seed and moist soil.

Cotton spaced closely did not greatly outyield that more widely spaced in tests by the Arizona, Missouri, and Texas stations, whereas in South Carolina the closer spacing gave the better yields. Over several years at the Pee Dee substation, close spacing of plants in the drill gave a higher percentage of the crop at first picking and a greater total yield with all varieties. In Texas in dry years the wider spacing made materially larger yields.

Highest cotton yields were obtained by the Arizona station when irrigation water was applied at 2-week intervals during blooming on the clay loam at the Salt River Valley farm, at 10-day intervals on the rather sandy soil at Tucson, and at 4-week intervals on the heavy soil at Yuma where the water often carries much silt. Cotton grown by the South Carolina station in soil with a high moisture content shed a larger percentage of fruit buds than did plants under soil moisture conditions near optimum. Such increase in shedding was associated with a lower percentage of oxygen and a higher percentage of carbon dioxide, observed in flooded plats in contrast to unflooded plats.

From a study of the order, rate, and regularity of blooming in cotton, the Arkansas station, considering also the results of others, concluded that only slight differences in the rapidity of blooming of cotton are caused by differences in species, variety, altitude, latitude, season, or cultural practice. It seemed almost impossible to make cotton bloom rapidly, yet the number of flowers per plant, per row, or per day might be increased by enlarging the plant.

Continuing extensive studies on factors influencing growth and development of cotton buds and bolls, the South Carolina station observed that defoliation of branches appreciably reduced the final size of bolls, and average weights of seed and lint. Shedding of bolls increased as the result of early defoliation, ringing, or removal of leaves adjacent to fruit buds five to seven days before blooming.

Potatoes.—The best conditions for good yields of high-quality potatoes, observed by the Washington station in a series of experiments, included a mellow sandy loam soil, a suitable rotation or a good green manure, sets weighing about 1 to 1¼ ounces dried for a few days or dusted with sulphur before planting, rather late planting, spacing 6 to 12 inches apart in 33-inch rows on fertile soil with abundant water, and irrigation to maintain uniform soil moisture throughout growth.

The Montana station observed that closer spacing or larger sets could be used in growing seed potatoes than for commercial potatoes. Larger sets were preferable to closer spacing, making for greater efficiency in roguing. Hills may be closer together or larger sets may be planted in more fertile and better-watered fields where conditions favor the proper development of the larger number of tubers formed.

That closer spacing of potatoes in the row tends to reduce losses from hollow heart, oversize and rough potatoes, and increases the acre yield of marketable tubers, was shown by Michigan station trials during five years on both fertilized and unfertilized soils and with summer rainfall above and below normal.

Exposure of freshly dug potatoes to the hot sun caused serious injury, the Washington station reported, whereas they could lie on the ground for three or four hours at 75° F. without harm. In harvesting during hot weather, direct exposure to the sun for more than a few minutes should be prevented.

Northern-grown seed potatoes yielded nearly 50 per cent more than home-grown seed stored at the same temperature at the Illinois station. Storage at 36° F. was best for both types, although northern-grown seed tended to yield better after higher temperatures and home-grown seed after lower temperatures.

The ethylene chlorohydrin treatment for seed potatoes, consisting of dipping cut sets in a 5 per cent solution for a short time and draining them, followed by 24 hours in an air-tight chamber, was found by the Nebraska station to be the most effective method for initiating early and general sprouting in dormant tubers. The efficiency of this chemical as measured by sprout growth was enhanced by applying it within not more than 48 hours—preferably within 24 hours—after cutting the tubers, planting in soil or other medium with a high moisture-holding capacity compared with sand, and by the use of large sets.

Greening seed potatoes before early planting has resulted in no benefits or in reduced yields in most experiments in the United States, although in northeastern Europe the maritime

climate has made it a standard farm practice. However, the Ohio station determined that for late June planting, indicated for seed-potato production, green seed of Russet Rural was much better than seed sprouted excessively in storage. For late June plantings the seed should be removed from storage before long sprouts develop and spread in the light to green, preferably outdoors in a coldframe. The West Virginia station observed that green sprouting caused quicker emergence but did not increase yields.

Potato seed from the spring crop exposed by the Oklahoma station to light for three weeks under shade gave better stands than seed taken directly from the field or from storage. Seed potatoes kept cool and moist 48 hours or longer after cutting by the Oregon station could withstand unfavorable conditions better than freshly cut seed which was more easily harmed by soil fungi and sunlight.

Sugar crops.—The percentage increase in number of commercial sugar-beet roots, yield, and in sugar production per acre usually was greater, in studies made by the Michigan station cooperating with the Department of Agriculture, as the soil was plowed deeper. The maximum increases came from fertilized land plowed 8 to 10 inches deep. While the sucrose and purity percentages fluctuated within narrow limits they had a very definite trend favoring fertilizer application and deeper plowing.

Sugar beets were transplanted by machinery, in Michigan station tests, at about the same cost as the ordinary seeding, blocking, and thinning operations, and one hoeing was eliminated. The transplanted beets yielded about one-third more than those seeded at the same time but were poorer in shape. Practical improvements in methods of seed production from sugar beets overwintered in the field were reported by the New Mexico station cooperating with the Department of Agriculture.

The importance of keeping sugarcane roots growing rapidly was emphasized in studies by the Louisiana station. Roots from the seed pieces maintained the young shoots until their own roots developed and shoots from stubble cane depended on the old stubble roots, showing that injury to roots during cultivation should be prevented so far as possible. To maintain a loose aerated soil, deep cultivation evidently should precede development of roots in the upper soil layers.

Tobacco.—Topping and suckering tobacco plants were found by the Connecticut tobacco substation to promote the development of the root system, to aid leaf growth, and to hasten the ripening of the leaves. Topping acted principally on the development of the root system; suckering resulted chiefly in better development of the net of fibrous roots.

Tobacco seed appeared to germinate best around 31° C (88° F.), in Wisconsin station experiments, although germination was satisfactory at ordinary room temperature. Wide differences in the length of time during which seed could retain germinability were revealed. The germination rate of seed 6 to 8 years old was quite satisfactory and seed even 9 to 12 years old might be used commercially with a probable delay of but two or three days in germinating.

Full-grown tobacco seed pods, according to the Wisconsin station, could be harvested while green and with white seeds, with fair certainty that the seeds might mature thereafter and germinate if dried and stored properly, whereas green pods not full grown when picked would rarely if ever produce viable seed. Freezing temperatures did not seem to damage mature seed pods, and light frosts evidently would not damage seed even in full-grown green pods.

Pruning the inflorescence of tobacco to fewer pods and also leaving some upper leaves on the stalk until the pods matured resulted in heavier seeds at the Connecticut tobacco substation. For heavy seeds all but 20 to 25 of the pods in the center of the inflorescence should be trimmed off soon after the first flowers fade.

Alfalfa.—When yield and quality of hay, labor distribution, and weather conditions were considered, the Montana station found that harvesting irrigated alfalfa at first bloom (new-growth stage) to one-half bloom was most feasible in the Gallatin Valley.

Waiting until afternoon to cut forage has no advantage so far as moisture content of green forage is concerned, according to Ohio station tests. After dew has dried from alfalfa, soybeans, and clovers the decrease in moisture content for the rest of the day practically never exceeds 3 per cent if the soil contains enough moisture so that the plants do not actually wilt. However, forage cut with dew off dried more uniformly.

Yields from alfalfa and sweetclover recorded by the Ohio station during the dry year 1930 were often much

greater, while those from red clover and timothy were decidedly less, when compared with averages for 11 years in rotations. Areas of alfalfa cut four times stored large quantities of root reserves and recovered much better than in normal seasons, suggesting that climatic differences are directly responsible for the fact that frequent and premature cuttings are not so injurious in the Western States as in the humid sections.

Alfalfa-seed production, according to the Utah station, is affected by a number of cultural and environmental factors. Quality in alfalfa seed apparently varied more as a result of seasonal conditions than because of differences in varieties or production methods. Alfalfa might be expected to seed best under desert or semidesert conditions of warm or hot days, cool nights, and relatively dry air both night and day. Artificial tripping in alfalfa seemed to result in greater stability and regularity in the subsequent behavior of the flowers. At the Michigan station where lack of proper pollination was an important factor limiting alfalfa-seed production, artificial tripping resulted in production of seed pods by three times as many flowers as under natural development, and in more seed per pod.

Clover.—Red clover may give better stands, according to Illinois station experiments, when sown on winter grain early. Fall clipping increased both hay and seed yields, while spring clipping decreased the seed yield. If hay is not needed, the first crop may well be cut for seed.

Frequent cutting, enough to maintain a reduced top growth resembling that resulting from pasturing, did not affect sweetclover stands much at the Kentucky station, although small root systems resulted. Cutting for hay at any time during the summer restricted root development and sometimes reduced stands; a late August cutting was most injurious, whereas late September cutting had little harmful effect. The relative food contents in roots were similar, regardless of the time of removing tops.

Soybeans.—Soybean plants grown by the Ohio station under reduced light, as under shade or in corn, contained less dry matter and total carbohydrates than those grown in the open. Such reductions were due in general to the development of less of the easily hydrolyzable carbohydrates, cellulose, and lignin, which contribute to toughness and rigidity of stems. Stems low in dry matter were relatively soft, succulent, pliable, and inclined to lodge. Soybeans cut by this station in August and early September in reasonably good curing weather, cured as rapidly and more uniformly in side-delivery windrows raked after wilting and turned occasionally, as they did when left in the swath to complete curing. Cut plants raked at once usually cured more slowly but made an excellent quality of hay.

The greatest benefit from inoculation of soybeans by the Illinois station came in heavier yields of beans, although succeeding crops were benefited somewhat. The crop itself profited more from inoculation than did the next crop, if the next crop was not soybeans also, and sometimes a crop thereafter was no better than after uninoculated soybeans.

Inoculated soybeans on the acid Grundy silt loam extensively developed in southern Iowa yielded twice as much hay and about three times as much seed as uninoculated soybeans in Iowa station tests. The protein content of the hay doubled and that of the seed increased one-third, such increases being greater when the soils were limed enough to neutralize acidity.

Other legumes.—Acre seeding rates for field peas depending upon the size of seed were found necessary by the Idaho station for maximum yields of the several varieties. Number of seeds per pound was the most accurate index to seeding rate. From four to five plants per square foot produced the highest yields regardless of variety, and optimum stands required 67 good seeds per square foot.

Austrian winter peas, according to the Oregon station cooperating with the Department of Agriculture, were best adapted to western Oregon, where the crop is winter hardy. The crop thrives with a well-prepared seed bed and October seedings at the acre rate of 75 pounds alone or of 60 pounds with from 3 to 5 pecks of small grain, and needs inoculation. It fits well in short-time rotation.

Several stations cooperated with the Department of Agriculture in determining the value of new legume crops. The Georgia Coastal Plain, Florida, and Oregon stations aided in determining the climatic, soil, and cultural and harvesting needs of monantha vetch, and demonstrated its value for hay, green manure, and pasture. Likewise the Georgia Coastal Plain, Florida, South Carolina, and Mississippi stations aided with Crotalaria, a new legume for the South.

Inoculation of legumes.—The Illinois station determined that for nodulation of legumes, cultures must be used under favorable conditions and must contain a large number of effective organisms. Nodulation may be better the second time the inoculated crop is grown on the land. Legume inoculants should be selected primarily on the basis of their ability to produce nodules and to increase yield and quality rather than for their ease of application to the seed. Cultures of the dry type were not so good as those prepared for use with water.

Nodulation obtained by the Missouri station by applying commercial dry inoculants to alfalfa seed did not equal that obtained from agar or soil cultures and was scarcely greater than that occurring by chance. The danger of obtaining ease of manipulation at the cost of efficiency in nodule production was pointed out.

Nodule bacteria were observed by the Illinois station to die rapidly after they were applied to soybean seeds; best results may be expected when the crop is planted soon after inoculation. When about 0.5 pint of liquid per bushel of seed is applied, inoculation can be made to advantage as the seeds are sown. Otherwise just enough seed for one-half day's planting should be treated.

Hay mixtures.—That hay-crop failures and poor yields can be avoided by proper combinations of forage plants was established by the Illinois station. The best grass-hay mixture included alsike clover and red clover in combination with the best hay grass, timothy. Cut twice per year, alfalfa with timothy outyielded alfalfa alone and the loss from alfalfa bacterial wilt disease was reduced markedly. Field peas or winter vetch with oats made the best early-emergency forage and Sudan grass alone or with soybeans the best late-emergency forage. The Montana station reported that mixtures of alfalfa and bromegrass, indicated for stands to be down for only two or three years, returned higher yields than alfalfa and timothy mixtures, suitable for longer periods, or alfalfa alone.

Mixtures of either summer or winter hay crops usually outyielded single plantings at the Alabama station, oats with Austrian winter peas leading the winter crops. Sudan grass-soybean mixtures could compete with weeds more successfully than soybeans alone in New Jersey station experiments, and forage yields were higher and the mixture was much superior to grass hay in chemical composition, although inferior to legume hay.

Pastures.—On western wheatgrass range, the Colorado station found that the deferred and rotation systems, compared with continuous grazing by cattle, resulted in more stalks per unit area and contained more of desirable species. Rotation grazing, where from 12 to 15 dairy cows pastured a 1-acre field for short periods, produced forage of much better quality than did a single large pasture at the Western Washington station. The Oklahoma station found that rotated pasture was in much better condition as to grass than continuous pasture, contained much fewer weeds, and excelled in beef production.

Experiments with a perennial bunch grass (*Stipa pulchra*) by the California station demonstrated that grazing or other harvesting should be kept at a minimum during intervals of rapid growth, and that the greatest use should follow after growth has stopped and the herbage is mature. The losses observed in *S. pulchra* and *Bromus hordeaceus* resulting from frequent removal of herbage by grazing or cutting, as well as those resulting from heavy grazing during most rapid growth, indicated that such practices decrease the yield and shorten the life of perennial bunch grasses.

Frequent mowing of pasture grasses by the Florida station gave about as satisfactory yields and a higher protein content than mowing less often. Bahia, carpet, and centipede grasses cut often remained more vegetative, contained more protein and minerals, and consequently were superior for feed.

The beneficial effects on pasture of disking, reseeding, manuring, and fertilization, particularly with a phosphatic fertilizer, were demonstrated in experiments by the Iowa station.

On native pasture land, the Kansas station found that unburned areas yielded the most vegetation, fall-burned the least vegetation, and late-spring-burned the fewest weeds. Since burning reduces yield of vegetation, pastures should be burned only when much old grass would affect the even distribution of the livestock.

On burned-over land high up in the Coast Range where forage plants encounter bracken fern and unfavorable soil conditions, the Oregon station obtained best results by burning in late August with immediate seeding in the ash. The better-adapted grasses were orchard grass, redtop, English ryegrass, timothy, and reed canary grass.

For reseeding ranges, chamiza, blue grama grass, and in the colder sections, smooth brome grass were among the most promising species in New Mexico station studies. Artificial reseeding, especially where there is already much vegetation, usually requires plowing or similar soil preparation before planting, and possibly at least one or two cultivations early in the growing season for weed control. Some range, however, could be improved materially by broadcasting seed of chamiza or blue grama grass with little or no soil preparation.

CROP NUTRITION

Research designed to determine the plant-food needs of the principal field crops, the best and cheapest sources of such nutrients, the most productive methods of applying them, and the practices best for the crop on a particular soil type was reported on by a number of experiment stations. A definite trend away from the conventional type of experimentation has been accompanied by refinement in technic, as applied especially to the study of nutritional deficiency symptoms, mode of action of specific nutrient elements, and essential elements not previously considered important in plant nutrition.

Cereals.—A general relationship between the color of the expressed sap of corn and the productiveness of the soil on which the corn grew was observed by the Virginia station. Colorless and light-brown saps indicated a fertile soil, while dark-brown color was associated with unproductiveness. Color characters of the sap were variously associated with abundance or deficiency of nitrogen, potassium, and phosphorus in the soil. The hydrogen-ion concentration of the sap was correlated with potassium fertilization, saps from plants receiving potassium generally being below pH 5.45 and that from plants receiving no potassium being above that point. The rate and severity of lodging indicated needs for potassium, since applications of potassium were accompanied by better root anchorage.

The total quantity of phosphorus absorbed and retained by the growing corn plant was found by the Illinois station to be fairly constant for a given strain of corn. Yields of corn and wheat were only slightly higher after cornstalk residues plowed under than after cornstalk ash, a fact of significance because most cornstalks may have to be burned as a control measure for corn borer.

Observing that roots of corn planted in four soil types tended to develop horizontally in early growth stages and to remain at comparatively shallow depths, the Michigan station pointed out that fertilizer placed on either side of the seed and slightly below it would be in the direct line of root growth and should be of benefit to the young plant earlier than when placed directly below or above the seed.

Fertilizer applied for corn in various positions with relation to the seed, the Delaware station found, gave best results with 125 to 250 pounds per acre in parallel bands slightly above the seed. A localized treatment not touching the seed seemed much better than hill applications in contact with the seed or broadcast. Hill applications were also found superior to broadcasting by the Massachusetts station. In wet, backward seasons, fertilizer treatments, especially in the row or hill, were most effective in speeding up maturity of corn in Indiana station experiments.

The best fertilizer treatment for rice found by the Texas station was 100 pounds per acre of ammonium sulphate at planting. Fertilizer evidently could not be used profitably on land badly infested with weeds without actually decreasing the rice yield. Somewhat similar observations were made by the Arkansas station where efforts to increase rice yields by the usual methods of fertilization were negative. Fertilizing rice after seeding seemed a better practice than applying fertilizer at planting or at intervals before planting.

Spring top-dressing wheat with nitrogen carriers was found by the Indiana station to be effective and practical in increasing yields and in lowering the cost per bushel. Medium early applications might be expected to give the larger increases without increasing the protein content, whereas later applications enhanced the protein but returned smaller yield increases. The best gains in yield were obtained on sandy loam soils.

Winter wheat on Kirkland sandy loam, the Oklahoma station found, made a noteworthy response to phosphorus, especially when that element was used with potassium, the best combination being superphosphate 225 pounds and kainite 75 pounds per acre, whereas wheat receiving nitrogen and potassium alone or in combination yielded less than unfertilized wheat. The protein content of the wheat rose with an increase in the

quantity of nitrogen applied. The grain receiving 300 pounds per acre of superphosphate contained the highest percentage of phosphorus and the plumpest kernels were produced on soil where kainite and superphosphate in equal quantities were applied.

Cotton.—Extensive fertilizer trials on cotton, made by the Mississippi station, indicated what probably are the most profitable fertilizer formulas for important soil areas outside the Delta. Recommendations were for the northeast prairie soil types, including black prairie 8–4–0 (N–P–K), red prairie 8–8–4, and sandy bottom soils 4–8–8; for shortleaf pine, northeast highland, flatwoods, and longleaf pine areas 8–8–4; and for brown loam soils—hill land 8–8–8, and bottom land 4–8–8.

Concentrated fertilizer mixtures in North Carolina station tests were as effective on cotton as the ordinary mixture of commercial materials on Norfolk sandy loam, but the commercial mixtures excelled on Cecil clay loam. Applying the fertilizer 10 days before planting gave better yields and control of fertilizer injury.

That fertilizer injury could be avoided by applying fertilizer 10 days before planting was also observed by the Georgia station. When fertilizer was thus applied stirring fertilizer and bedding gave a slightly better stand than not stirring. Small quantities of limestone markedly increased the stand when combined with acid-forming nitrogen carriers such as ammonium sulphate and urea but not with sodium nitrate. Application of limestone was favored on the clay soil of the piedmont, whereas either no increase or else a decrease in seed-cotton yields followed limestone applications on the sandy soils of the coastal plain. Dividing applications of ammonium sulphate, potassium, or large quantities of complete fertilizer, was superior to placing them under cotton all at planting.

Applying all of the fertilizer in the drill before planting cotton in Texas station tests at Troup, resulted in larger yields than when one-half the nitrogen was side dressed after the cotton was chopped. At several Texas substations fertilizers either failed to increase yields consistently or were unprofitable.

Potatoes and root crops.—In fertilizer experiments with potatoes during eight years, the South Carolina station obtained best results on sandy river bottom soil from 1 ton per acre of 5–7–5 (N–P–K) fertilizer plus 100 pounds of sodium nitrate; at the Pee Dee substation on fertile Orangeburg sandy loam from 1 ton of 5–7–5; and at the Coast substation from 1.5 tons of 5–7–5. One source of potassium seemed as good as another, although omitting potassium reduced acre yields about 10 barrels.

Concentrated fertilizers, applied to potatoes in several localities by the New York (Cornell) station cooperating with the Department of Agriculture, produced about the same yields as standard mixtures providing the same quantities of nutrients.

Comparing nitrogenous fertilizers for potatoes during 16 years, the Maine station and the Department of Agriculture observed that ammonium sulphate produced a higher average yield than sodium nitrate, although comparative results seemed to depend largely upon seasonal conditions. The major effects of seasonal variation appeared to be leaching of sodium nitrate during periods of heavy rainfall and the unavailability of ammonium sulphate during drought, especially on very acid soils. Mixtures with part of the nitrogen in organic form were better in certain years with heavy rainfall early in the growing season, but in general did not produce a great increase over mixtures containing only inorganic salts.

The frequent difficulty of getting sweetpotato sprouts to live after heavy fertilizer treatments at or just before transplanting was largely overcome by the North Carolina station by applying the fertilizer after the plants were set and rooted. Applying one-half before transplanting and one-half later eliminated most of the injury. Mixtures deriving their potassium from low-grade carriers such as kainite were much more injurious than those deriving potassium from the chloride.

Working with sugar beets on several soil types, the Michigan station found the most profitable fertilizer mixtures to contain nitrogen, phosphoric acid, and potash, in the ratios 1–4–1 and 1–4–2, with the greatest returns usually coming from 400 to 600 pounds per acre of 4–16–4 or 4–16–8 fertilizers. Soils more productive and containing more organic matter responded to even larger applications. On soils having plenty of organic matter the benefits from nitrogen application depended upon the use of a soluble carrier in early spring to start the young plants quickly.

That certain soil conditions and fertilizer treatments seemed to enable sugar beets to absorb mineral nutrients in quantities and ratios favorable to growth, was reported by the Mich-

igan station. The optimum was found on Brookston silt loam receiving 100 pounds per acre of sodium nitrate, 400 pounds of superphosphate, and 100 pounds of potassium chloride. Seasonal fluctuations in contents of mineral nutrients were found to vary with the soil, fertilizer, and stage of growth. Usually the percentages of minerals were highest in the spring, low during the summer, and, if enough minerals were present in the soil, high in the autumn. The sugar content usually was highest on the plats that produced the best yields of beets on each soil.

Tobacco.—Based on their extensive fertilizer experiments and experience the Virginia, North Carolina, South Carolina, and Georgia Coastal Plain stations, the Georgia College of Agriculture, and the Department of Agriculture united in recommending for the 1932 crop of bright flue-cured tobacco on the heavy or more productive soils, fertilizer mixtures containing 3 per cent of ammonia, 8 per cent of available phosphoric acid, and 5 per cent of potash, with an additional 1 per cent each of ammonia and potash for light or less productive soils, the mixture applied at the rate of 800 to 1,200 pounds per acre in the drill within 10 days before transplanting. To control sand drown, that is, magnesia hunger, fertilizers should carry 2 per cent of magnesia. The nutrients were to come from certain approved carriers, and the mixtures should contain a maximum of 2 per cent of chlorine. The mixture for dark tobacco, ammonia 3 per cent, phosphoric acid 8, and potash 3 per cent, was to be used at the rate of 600 to 1,000 pounds per acre. For plant beds a modified fertilizer from the same sources, and including 1 per cent of available magnesia and not more than 1 per cent of chlorine was advised.

The best fertilizer combination for dark tobacco on typical dark-tobacco soils in Virginia station tests was 80 to 100 pounds each of ammonia, phosphoric acid, and potash per acre. High-grade complete fertilizers in relatively heavy applications were more profitable than lighter applications. Dried blood was superior to sodium nitrate or ammonium sulphate, yet it appeared desirable to furnish the nitrogen from both organic and inorganic carriers. There was little difference whether potassium sulphate or chloride supplied the potassium.

The source of potassium for tobacco, whether the sulphate, carbonate, or nitrate, or a combination, made little difference at the Connecticut tobacco substation. Ground tobacco stems, both here and at the Massachusetts station, provided a good source of potassium and were otherwise desirable as fertilizer material. From 20 to 40 tons of manure per acre greatly increased the prevalence of black root rot, the most probable cause of decreasing yields where manure was applied. Cigars from leaf grown on plats receiving magnesian lime held fire longer than those from unlimed plats, had a lighter-colored ash and a narrower coal band, and in general, were superior in taste and aroma. A certain amount of magnesia in the leaf, about 2 per cent, appeared essential for satisfactory combustion in the cigar.

When tobacco succeeds timothy, and the nitrate content of the soil is low at the time of transplanting tobacco and is not corrected by fertilizer, the Wisconsin station observed that the growth of tobacco invariably is poor, especially in the less fertile and more acid soil, and brown root rot generally is present. Soils producing tobacco affected with brown root rot always contained much cellulose material. Heavy application of nitrogen and phosphorus fertilizers under such conditions tend to produce nearly normal tobacco and few brown roots.

Forage crops.—The improvement of pastures by proper fertilizer treatment has aroused widespread interest in recent years. The better areas of permanent pasture, the New Hampshire station observed, would respond profitably to fertilizer. Some pastures, mostly grasses, responded more to nitrogen, whereas the pasture with a partial stand of white clover at top dressing made a good response to potassium, phosphorus, and lime. Supplying plant food tended quickly to stimulate Kentucky bluegrass and bentgrasses and, on the heavier soil types, white clover, crowding out the undesirable species.

Factors responsible for the lowered productivity of Wisconsin pastures, according to Wisconsin station experiments, included inadequate supplies of lime, phosphorus, potassium, and nitrogen, close and heavy grazing, especially in early summer, depredations of white grubs, and the lack of good species of grass and legumes to replace inferior species or weeds. Examples of the effects of remedial measures were the striking responses made to fertilizers and liming on bluegrass pastures and to rotation grazing on mixed permanent pasture.

Nitrogen applied to pastures in large quantities by the Virginia station increased the protein content of grasses, the carrying capacity for cattle, and the grazing season, but decreased the quantity of white clover present. Young tender grasses were very high in protein, and where much nitrogen was applied, dry-matter yields were very high early in the season. The yield and percentage of protein diminished during summer but increased again in the fall. Dried clippings compared favorably with cottonseed and peanut meals as a protein concentrate.

Little effects may be expected from lime, phosphorus, and potassium in the same year they are applied as top dressing to pasture, according to Massachusetts station studies, whereas all forms of nitrogen are more or less effective the first year.

A good turf of bentgrass could not be maintained by the Kansas station without fertilizers, the best turf being obtained by the use of both fertilizers and compost. Nitrogen treatments were followed by increases of 300 per cent in yield of clippings from bluegrass and over 500 per cent from Washington bent. Clover predominated in unfertilized bentgrass, while very little appeared in plats treated regularly with fertilizer and compost.

In alfalfa experiments in central and eastern Oklahoma, on soils good physically but low in available plant food, the Oklahoma station found that adding green manures, manure, or straw did not increase alfalfa yields much more than did mineral fertilization alone. Low availability of soil phosphorus seemed the chief limiting factor in alfalfa production, and from 150 to 200 pounds of superphosphate per acre annually was indicated. The largest increases came from the combination of manure and superphosphate top dressed on the alfalfa sod in spring. Many soils needed limestone for maximum alfalfa production, and except on the most acid soils, had a greater influence in holding the stand than in increasing crop growth during the first or second season.

Sweetclover is more effective for increasing crop yields on many soils when fertilizers containing potassium are used, according to Illinois station findings. When available potassium is lacking, accumulation of nitrate nitrogen may unbalance the crop's food supply, a condition to be corrected through the use of potassium salts. Conversely some unfavorable results reported from the use of potassium might be avoided by using available nitrogen.

CROP ROTATION

The advantages of crop rotation in maintaining and increasing crop yields, in rendering fertilizers more profitable, and in promoting orderly crop production have been widely recognized, yet crop-rotation problems are much more complex than has been generally realized. Many phases of these problems remain to be solved, even after prolonged and varied investigation by the stations.

The study of crop rotations and tillage methods on dry land in the Great Plains, recently reported by the Department of Agriculture from field experiments made in cooperation with the Kansas, Montana, Nebraska, North Dakota, and Wyoming stations, and independently, is outstanding as a cooperative attack on crop-rotation problems made over a long period under unusual conditions.

In prolonged Utah station studies at Logan rotation was found nearly as essential to small grains as was manure for sugar beets and was also important for potatoes, alfalfa, and corn, and on nematode-infested land, was necessary for sugar beets. A sequence including alfalfa and cultivated crops, with moderately heavy manuring, best maintained high yields of all the crops studied.

Wheat, as its yields in experiments by the Oklahoma station indicated, preferred preceding crops in the following order: Cowpeas, corn, spring grain, milo, and wheat. With milo, however, the kind of previous crop was of less importance than the preparation and spacing. Cowpeas did uniformly well following a cultivated row crop, but yields fell to unprofitable levels after any kind of broadcast seeding, including small grains and sorghums grown for hay without cultivation.

Alfalfa-rotation experiments made by the Minnesota station in western central Minnesota showed that corn was the most satisfactory crop to follow alfalfa; it seemed to be affected less than wheat or barley by the depleted reserve of subsoil moisture. The place for grain crops following alfalfa is in the later years of the rotation.

For maximum benefit to potatoes alfalfa should remain down at least three years, the Montana station noted. Alfalfa and red clover largely increased yields of crops immediately following them, yet beneficial effects

were apparent several years after the legumes were plowed up. The beneficial effects of alfalfa and manure in the rotation in maintaining or increasing crop yields continued to feature irrigated rotation experiments at Huntley made in cooperation with the Department of Agriculture.

The effectiveness of rotation in controlling such perennial weeds as Canada thistle was proved by the Montana station. Four-year rotations including one year of red clover or 6-year sequences using three years of alfalfa controlled Canada thistle, whereas this weed became serious under continuous cropping or in short-time rotations of grain crops.

Tobacco.—Studying the effects of certain crops on others following them in rotation, the Virginia station cooperating with the Department of Agriculture observed that small grains and grasses do better after potatoes or tobacco than after corn or other small grains fertilized similarly; that tobacco yields may be maintained as well under continuous cropping as in rotations, if liberal quantities of fertilizer are applied; and that vetch, cowpeas, soybeans, and crimson clover, well inoculated, supply the nitrogen needs of tobacco and corn which follow them in rotation.

Rotations wherein tobacco followed orchard-grass sod, in Kentucky station experiments, gave good results where manure or nitrogen fertilizers were used, while tobacco after alfalfa produced leaf of a poor quality. In 3-year rotations, manure greatly benefited both yield and quality of leaf, tobacco-wheat-clover and tobacco-wheat-soybean sequences giving a better leaf than a tobacco-red top rotation.

Planting mosaic-infested but otherwise desirable tobacco fields to corn for one year and then returning them to tobacco, the Wisconsin station observed, would practically control mosaic arising from the field source and would not introduce into the tobacco land much of the harmful effects often caused by other crops in the regular rotation.

Effects of sorghum.—The depressing effects of sorghum upon the yields of succeeding crops were considered by several stations.

Grain sorghum varieties studied by the Texas station differed somewhat in their effect upon the crop of oats following; all sorts reduced oats yields considerably but did not lower the yield of sweetclover. It appeared that sorghum stubble and stalks should be turned under soon after harvest in order to have as much time as possible for decomposition before the next crop.

No toxic effect appeared in crops following the grain sorghums on fertile soils, and in soils low in organic matter, sweetclover grew better after kafir than after soybeans, according to the Oklahoma station. The depressing effect of sorghum compared with that of corn could not be explained satisfactorily by differences in chemical analyses.

CROP QUALITY

Overproduction of certain crops in recent years and the consequent reduction in profits has tended to emphasize the merits of quality rather than acre yield in farm products. This has stimulated agronomists to seek the conditions in soil or culture, fertilizer, or harvest practice that furnish longer fibers, better aroma, flavor, and burn in tobacco, higher protein content indicative of bread-making value in wheat, and quality characters in other crops.

Food crops.—Practices producing wheat high in quality and yield and largely within the control of the farmer, the Montana station reported, included manuring, rotation with legumes, and clean fallow or summer tillage. It observed that fallowing dry land usually resulted in more nitrates in the soil and produced wheat much higher in protein than wheat on land cropped continuously.

That legumes preceding wheat increase its protein content was observed by the Kansas station. It appeared that the longer a field was in alfalfa the higher would be the protein content of wheat from that field. Soil treatments, such as rotations and fertilizers, which gave a seed bed well supplied with nitrates, produced high-protein wheat.

Environmental conditions in central and southern Illinois, according to Illinois station studies, are not conducive to growing winter wheat, either hard or soft, which mills into strong flour. Flour milled from winter wheat from northern Illinois usually will have good to excellent baking quality. A few varieties of winter wheat could produce flour of good quality, in spite of the unfavorable environment of central Illinois. Hard spring wheat of high protein content which will mill into flour of excellent strength might be grown in both central and northern Illinois. However, it seemed doubtful if Illinois could consistently compete

with the West and Northwest in producing high-grade bread wheats.

Fiber crops.—Length and uniformity of staple in cotton grown in gin areas in four counties, the North Carolina station and the Department of Agriculture found, were associated directly with the selection and care of seed stocks. Pure seed of improved cottons not only made high yields, but also produced staple superior to that from mixed seed of the same varieties or from short staple, mixed, or run-down varieties.

The greater strength of cotton from good land compared with that from poorer soils indicated to the Oklahoma station that nutrients as well as water are needed for quality in cotton fiber. Cotton from bottom land was decidedly superior in quality to cotton from upland soils. Cotton left unpicked in the field was found to deteriorate, that is, to start breaking down and to become weaker. Varieties with the longest staples usually were the strongest.

In ginning experiments with cotton of various staple lengths the Texas station observed that in general a saw speed of 760 revolutions per minute, together with the loose breastroll and standard air-line cleaner, provided the best ginning conditions on the air-blast type of gin used. The air-line cleaner improved the grade of the fiber and the type of ginning.

Fiber flax should be harvested during the yellow-ripe stage for best yield and quality of both fiber and seed, according to studies by the Michigan station cooperating with the Department of Agriculture. Fiber flax on the heavier soil types in Michigan yielded much more straw and fiber than on lighter soils, even when fertilized. Potassium when applied with phosphorus returned increased yields of fiber and seed, whereas nitrogen was not very effective. Application of calcium-magnesium lime usually increased the yield of scutched and hackled fiber and the percentage of fiber in threshed straw.

Tobacco.—The best yields and quality of Burley tobacco in eastern Tennessee, the Tennessee station determined, were made on soils derived from high-grade limestone and Tellico sandstone, on soils with surface layers 15 inches or deeper, with manure applications of 14.4 tons per acre, with fertilizers, and where red clover was the preceding crop.

The quality of tobacco in Connecticut tobacco substation studies was lowered by reducing the potassium in the fertilizer and by using urea as the sole source of nitrogen, but was improved by applying magnesian lime. About 2 per cent of magnesia in the leaf seemed essential for satisfactory combustion in the cigar.

In duration of burn of shade tobacco, leaves from different fertilizer treatments differ significantly, the Florida station found. The longest burn, 15.6 seconds, occurred on leaves receiving nitrogen from manure and cottonseed meal, while the shortest burn, 6.5 seconds, took place when the nitrogen came equally from cottonseed meal and castor pomace. Copper compounds applied to tobacco increased the percentage of uniformly colored leaves, while compounds of other elements used, except iron, were injurious in this respect. Copper, iron, and zinc increased the duration of burn, while boron and manganese reduced it to about half that of the check.

The good grades in several crops of Burley and of dark tobacco were found by the Kentucky station to contain noticeably higher percentages of potassium, chlorine, and sulphate sulphur than corresponding common grades. The Massachusetts station determined that the nitrogen content of leaves and stalks of Havana tobacco was variously affected by fertilizers, cultural practices, and rotations.

That the optimum temperature for curing tobacco lies between 90° and 95° F., provided a high enough humidity is maintained, was observed by the Wisconsin station cooperating with the Department of Agriculture. However, the ordinary range of constant temperatures permitting about normal curing, assuming favorable humidities, lies between 65° and 100°. The optimum relative humidity for curing depends upon the temperature; in general, between temperatures of 75° and 100°, a percentage relative humidity corresponding to the temperature figure is deemed satisfactory.

Where shade tobacco was cured under controlled conditions, the Connecticut substation noted that temperature and humidity markedly influence color, texture, grain, and prominence of veins. Relative humidities of 80 to 85 per cent were optimum for most conditions. With this humidity range, the optimum temperature for the early pickings was about 95° F. and for later pickings 85° to 90°. In heating tobacco sheds, this substation saved more than 40 per cent of the fuel cost by using coke instead of charcoal. Coke gave a steady, practically

odorless and smokeless heat, which, with suitable salamanders and spreaders, was well distributed and the tobacco had no objectionable odor or injury.

WEEDS

The demands for effective and economical methods for controlling weeds by chemical herbicides, cultural practice, or rotation were being met in special studies at a number of stations.

Chlorates offer a promising means of easily and cheaply eradicating noxious weeds before they spread to an entire farm, although cultural methods still appear cheapest for large areas. Indications are that toxic effects of chlorate treatments usually do not remain in the soil longer than one year. The Illinois station obtained best results with chlorates on Canada thistle but had only fair success with wild garlic, quack grass, and horse nettle. Fall applications were the best, October seeming slightly better for wild garlic and quack grass. Spring and fall applications gave good results with Canada thistle. Very early and very late repeated applications with smaller quantities of chlorate seemed better than a larger quantity applied at one time. A serious objection to the use of chlorates as weed killers is the danger from fire.

Perennials were also effectively destroyed by chlorates at the Oregon and Wisconsin stations. Sodium chlorate was most effective for quack grass when applied June 20 and October 20 by the Iowa station, while the West Virginia station found December and April treatments the best. At the latter station applications were even more effective on dried tops than on green leaves and stems.

For killing bindweed, the Kansas station found that calcium chlorate and magnesium chlorate in quantities equal in chlorate content were as effective as sodium chlorate. Delay in treatment saved material and labor; three applications begun in August were as effective as four begun earlier.

The catalase activity of roots of bindweed, according to Washington station studies, decreased greatly after the plants were sprayed thoroughly with sodium chlorate. For complete eradication of bindweed the chemical evidently must be toxic enough to distinctly lower the catalase activity of the roots to a depth of 2 feet.

Ethylene oxide and propylene oxide, according to Minnesota station studies, may be useful in the control of barberry, poison ivy, prickly-ash, and other noxious plants, and have advantages over current methods in ease of handling, toxicity in small concentrations, and rapid release from the soil. Ammonium thiocyanate, used 1 to 5 pounds per gallon of water as a spray, killed thistles, burdock, poison ivy, and other weeds. Its merits included a short period of toxicity to crops and a possible fertilizer value.

For controlling weeds in rice, the Arkansas station found rotation with soybeans to be the best method tested, and to result in increased rice yields.

Weeds in beans and corn were controlled most efficiently by the Michigan station by using the rotary hoe three or four times when weed seedlings appeared aboveground and following once or twice with the duck-foot cultivator.

In efforts to control quack grass, the North Dakota station found that early fall tillage was more promising than late tillage and should be practiced on land that can not be summer fallowed; summer tillage was effective where feasible. The control obtained was in direct proportion to the thoroughness of tillage, timeliness of operation, and favorableness of the weather. The 1-way disk tiller gave the most promising control at the least cost, although the field (duck-foot) cultivator and plow methods with disking, were only slightly less efficient when the work was well done.

St. Johnswort, the most serious weed on ranges and pastures of northern California, could be controlled in small areas, the California station observed, by spraying with sodium chlorate in early spring and autumn. Prevention of seeding and destruction along roads and waterways was advised.

HENRY M. STEECE.

HORTICULTURE

Many of the problems undertaken by station horticulturists have a distinctly practical bearing, and certain of the results secured have contributed very definitely to the prosperity of commercial horticulturists.

For example, investigations at the Oregon and Washington stations which resulted in devising a dilute hydrochloric acid wash for removing arsenic and other residues from apples and pears. The method has been of great financial benefit to fruit growers not only of that region but all over the country. The results were of particular importance in the irrigated sections of the Northwest where the limited rainfall during the growing

season was a contributing factor to large residues.

Fruit-breeding studies at the stations are now yielding practical as well as scientific results. The Cortland apple produced by the New York State station from a McIntosh×Ben Davis cross is being widely planted in the McIntosh region as a late variety to lengthen the McIntosh season. The Latham raspberry bred at the Minnesota station, and characterized by vigor, productivity, and resistance to virus diseases, is planted wherever red varieties are grown. Several of the peaches developed by the New Jersey stations are taking a place in the commercial orchards of that State.

Results of pollination experiments have had a decidedly practical aspect. For example, the findings by the Oregon station that Napoleon, Bing, and Lambert sweet cherries were self-sterile and also intersterile but could be satisfactorily pollinated by Black Tartarian and certain other varieties, saved cherry growers thousands of dollars and much wasted effort. The discovery at the New Jersey stations that the J. H. Hale peach is almost completely self-sterile solved a very troublesome problem in fruit setting for the growers.

The Ohio and Maryland stations recently rendered an important service to apple growers by proving that nitrogenous fertilizers, even when used in rather large quantities, have no direct influence on the keeping quality of apples. This finding is important because of apple buyers' growing disposition to discount the prices of fruit grown in orchards fertilized with nitrogen.

POMOLOGY

Pollination problems.—Competition for nutrients among the several flowers of the cluster rather than a lack of pollination was found by the Ohio station to be a factor in the first drop of flowers in the Stayman Winesap apple. The terminal flower was strongest and, if uninjured, apparently depressed the set on the laterals. Among the laterals, a flower subtended by a leaf was best able to compete with the terminal. In Jonathan apples the terminal flower was not so dominant as in Stayman Winesap. In pollination experiments the Stayman Winesap was found highly self-unfruitful; Delicious, Starking, Golden Delicious, Grimes Golden, and Jonathan were effective pollinizers.

In cage pollination tests at the New Hampshire station Delicious proved a most reliable and consistent pollinizer for McIntosh, while Baldwin did not give favorable results. McIntosh was an excellent pollinizer for Cortland, good for Gravenstein, and fair for Delicious. A strong correlation between the number of seed and the weight of McIntosh apples suggested that good pollination serves to increase the size as well as the number of apples.

Some evidence on the rôle of the weather in apple pollination was obtained by the New York (Cornell) station. Hives of bees and bouquets of an effective pollinizer placed in one orchard greatly increased yield, but gave negative results in another orchard that bloomed during rainy, cold weather.

Evidence that the pollen directly influences the shape of the fruit was obtained by the New York State station in experiments with Fameuse apples pollinated with Yellow Bellflower and McIntosh. In width, the Fameuse × McIntosh apples were distinctly less variable than the other lot.

In studies of pecan fertilization the Texas station showed that about four weeks elapse between pollination and fertilization, and the extensive dropping of nuts often occurring about four weeks after pollination is ascribed to lack of fertilization. No evidence of self-incompatibility or interincompatibility was observed.

That certain filberts may be self-unfruitful was observed by the New York State station. For example, Barcelona and Rush pollen failed to satisfactorily fertilize Barcelona flowers, whereas Rush was successfully pollinated with Barcelona.

Fruit-bud formation.—Evidence that fruiting habits once established in fruit trees are difficult to change was found by the New York (Cornell) station. Wealthy apples about 20 years old failed to change the biennial-bearing habit although receiving very large applications of sodium nitrate several years in succession, supplemented in certain cases with heavy pruning. It was found possible by heavy applications of sodium nitrate to alter the carbohydrate-nitrogen ratio within rather wide limits without influencing the fruiting performance of established biennial-bearing apple trees.

Finding that spurs of nonbearing Sugar prune trees were consistently higher in starch than those of bearing trees and that the roots of nonbearing trees were also high in starch, the California station suggested that carbohydrates may be limited sufficiently in the roots of heavy-bearing trees to

suppress root growth and thereby indirectly the intake of ions and water needed for fruit-bud formation. Starch itself is deemed probably unnecessary for fruit-bud formation but may represent a nutritive condition of excess-energy materials that underlie the process.

Studying the effects of pruning on fruit-bud formation in the peach the Michigan station concluded that pruning practices in the peach orchard may be planned without much heed to fruit-bud formation or fruiting habit. Severe pruning resulted in very low and unprofitable yields, because of unfavorable distribution rather than lack of buds. At the same station the fact that Lombard plum trees, the fruits of which were thinned, made more growth the same year, carried more leaves on spurs, apparently developed more secondary spurs the succeeding year, and two years later, without further thinning, outyielded unthinned trees, suggested that thinning should be regular, since overbearing followed occasional thinning.

Separating spurs of 20-year-old Yellow Transparent apple trees into cluster bases and secondary growths, the Delaware station found that, regardless of fertilizer treatment, the cluster bases averaged higher in percentage of moisture, total, soluble, and insoluble nitrogen, total sugars, sucrose, free reducing sugars, polysaccharides, and total carbohydrates than did the secondary growths. Nitrogen fertilizers influenced the total nitrogen in the cluster base much more than that in the secondary growth.

Physiological studies.—All oils sprayed on the leaves of deciduous-tree fruits by the Illinois station retarded transpiration in all the species studied. Spraying the upper surface had no effect on transpiration; in fact, spraying both surfaces had no more reducing effect than spraying only the lower surface. The stomata of oil-sprayed leaves did not open so widely as those of unsprayed leaves.

Changes in sap concentration in mature lemon and orange leaves, the California citrus station observed, were inversely related to temperature of air and soil, but had no connection with sunlight and humidity. The quantity of various inorganic constituents in dried leaves and in the sap was apparently more closely related to the age of the leaf than to environmental changes.

The stone cells of pears were found by the Michigan station to contribute to the firmness of the fruit, and to aid in healing and preventing wounds. They influence quality through their effect on texture and on the nature and concentration of chemical constituents determining sweetness and flavor. The presence of stone cells in pears is believed to rest on genetic bases, and it is suggested that any improvement in gritty pears must come from genetic recombinations.

In an ingenious test for distinguishing mazzard and mahaleb cherry roots, developed by the New York State station, pieces of mazzard root immersed in an iron-alum solution soon darken the solution, whereas mahaleb roots do not affect its color.

Observing the comparative inactivity of fruiting canes of red raspberry the Minnesota station concluded that cambial activity is relatively feeble in the older canes, being limited in some cases to the maturity of the phloem initials cut off late the first year and to an increase in radial diameter in the remaining cambial cells. Somewhat comparable studies by the Michigan station showed that fruiting canes of the black raspberry rapidly lose their capacity to transmit water, and at the close of the picking season may transmit only one-half as much water as when the berries were first formed. On the other hand, young shoots showed an increasing power of water transmission.

Strawberries with firm flesh are not necessarily of low respiration intensity, either when immature or ripe, according to experiments made by the Washington station. In fact, the firm-fleshed kinds studied had the higher respiration ratio.

Propagation studies.—Because much horticultural material is necessarily multiplied asexually in order to maintain desirable variations, propagation by cuttings, buds, and scions is of vital interest. The reluctance, in fact, the almost complete failure of many species, including such well-known fruits as the apple, to grow from cuttings has served to stimulate experimental work along these lines. Studying Coleus, the Iowa station showed that in softwood cuttings the quantity of foliage left on the cutting is of prime importance in its rooting, the certainty of rooting increasing with the leaf area. Working with the blueberry, the Mississippi station observed that cuttings taken at or just before the end of shoot growth and the start of root growth, rooted most successfully. Increase in leaf area up to 2 square inches per cutting favored root development. Rooting was not sig-

nificantly stimulated by chemicals. In the black raspberry, improved varieties of which are increased by plants produced at the tips of canes, the Michigan station found no essential difference between large and small tip plants, if the very small individuals normally discarded by commercial growers were excluded. Further evidence that 1-year-old apple trees may readily be propagated from root cuttings, a faculty soon lost as the tree grows older, was found by the Maryland station cooperating with the United States Department of Agriculture.

The nature of the rootstock of pears was found by Oregon station studies in the Hood River Valley to be a factor in resistance to winter injury, pear trees on Japanese roots being more subject to injury than those on French (*Pyrus communis*) roots. As concerned trunk injury, certain pears—Comice, Easter Beurre, and Flemish Beauty—were resistant, and others—Anjou, Bosc, Bartlett, and Winter Nelis—were susceptible.

Nutritional studies.—As refinements in technic have progressed, problems of soil fertility have increased in number and complexity. For example, at the Arkansas station, greenhouse investigations with the tomato indicated that the fertilizer program for greenhouse crops must be modified in accordance with the season. In midwinter, with sunlight conditions unfavorable to photosynthesis, it was found advisable to reduce the nitrogen supply, because apparently not enough carbohydrates were formed to combine with the available nitrogen, and soft, succulent, unproductive plants resulted. Substances formerly believed of no value and sometimes even toxic to plants are now being found indispensable. Boron in extremely minute quantities was shown by the California station to be necessary for citrus trees. The lack of boron apparently tended to result in the breakdown of the conducting tissues in the leaves, causing an overaccumulation of sugars and in extreme cases the breakdown of the entire plant.

Perhaps no orchard problem demands more attention than does the maintenance of organic matter in the soil. The Pennsylvania station concludes that any system of orchard management eventually influences yield mainly to the extent that it modifies the organic content of the soil. During the extreme drought of 1930 this station observed that trees in soil rather high in organic matter suffered the least injury from water shortage, and now advocates earlier planting of cover crops, with the purpose of adding more organic material to the soil. Incidentally the Pennsylvania station found that phosphorus fertilizers were becoming profitable in the orchards, apparently because they stimulate the cover crop and indirectly increase the organic-matter content. The belief that nitrogen alone is adequate fertilizer for orchard trees was also disproved by the Montana station working in the Bitterroot Valley, where weak apple trees recovered most rapidly when given complete fertilizers. In a Concord grape vineyard on a relatively poor soil the Michigan station observed that complete fertilizers are desirable, the addition of phosphates and potassium giving a substantial increase in growth and production beyond those increases secured with nitrogen alone. Evidence that peach trees apparently assimilate nitrogen during the leafless period when the temperature rises above 40° F. was obtained by the North Carolina station.

That fertilizers may directly influence the composition of the fruit was shown in Ohio station studies which indicated that sodium nitrate applied to apple trees in sod and in tilled soil had increased the actual quantity of nitrogen in the fruit, particularly on the sod-grown trees. Determinations of total sugars, sucrose, and reducing sugars did not show any significant difference attributable to fertilizer treatments.

An interesting sidelight was thrown on the soil-fertility problem by the New Jersey stations, where simply modifying the texture of a quartz sand by grinding produced decided differences in the growth of tomato cuttings. No nutrient was supplied in either case and no nitrogen was present in the sand, yet significantly better top and root growth were obtained in the ground sand.

Nitrogen and keeping quality.—Following statements by fruit buyers and others that certain nitrogen fertilizers lowered the keeping quality of fruit, the Ohio station compared apples from trees fertilized with sodium nitrate with apples from control trees. Although the nitrogen fertilizer increased the percentage of total nitrogen and the total amount of nitrogen in the fruits, and decreased the red color and rendered the apples more susceptible to scald injury, no consistent relation

between fertilizers and the amount of decay or breakdown in storage was established.

No marked influence on color or keeping quality of apples exerted by nitrogen fertilizers applied at different times in late summer was observed at the Maryland station. There was some indication that nitrogen applied in mid-August slightly lessened the firmness of York Imperial apples, but, since the same treatment did not affect Stayman Winesap or Rome Beauty apples, some other factor than nitrogen may have been involved.

Strawberries fertilized with nitrogen, the Ohio station found by using the pressure test, were slightly softer but not so soft as to affect shipping quality to any significant degree. As with the apple, the strawberries receiving nitrogen fertilizer contained more nitrogen than did the control fruits.

Cranberry studies.—The changes occurring in ripening cranberries studied by the Massachusetts station included a rapid increase in total sugars, the total acids remaining quite constant. The highest sugar content was attained in berries which ripened fully on the vines. In storage sugar was lost steadily through respiration, and total acids decreased gradually. The tart flavor, however, remained in the berries until they decayed. Since acid varied within narrow limits and sugar varied widely, quality evidently is correlated closely with sugar content. Similar studies made by the New Jersey stations showed that vine-ripened cranberries were higher in sugar than early harvested fruit. Sugar content was rather low, attaining a maximum of about 4 per cent and consisting almost entirely of reducing sugar. Ideal storage conditions for cranberries were found to include a temperature between 10° and 14° C. (50°–57.2° F.), high humidity, and diffused sunlight, under which berries kept well for six months. Ethylene gas was not an effective agent for ripening and coloring the cranberry.

Spray-residue removal.—Although the dilute hydrochloric-acid wash has been generally accepted as the best known means of removing arsenical and other residues from apples, pears, and other fruits, several of the stations continued to work on the improvement of technic and on the effects of washing treatments on the subsequent keeping of the fruit. Furthermore, the severe drought of 1930 greatly accentuated the problem in the Eastern States, where abundant rains usually aid materially in spray removal. Apple varieties, the Indiana station observed, differed greatly in their susceptibility to acid injury. Rome Beauty, Stayman Winesap, and Delicious were easily injured, while Ben Davis, Grimes Golden, and Winesap safely withstood concentrations above those needed to cleanse the fruit. The Ohio station found that the composition of the sprays had a considerable rôle in the degree to which residues adhered to the fruit. Adding lime to the spray reduced arsenical residues, the use of stickers increased them, and oils had little influence on the amount. According to analyses of apples collected in various producing sections by the New York State station only three lots carried arsenic in excess of the 0.01 grain of arsenious oxide per pound of fruit, indicating that spray removal is not currently a serious problem in New York. Packed apples averaged one-third less arsenic than did similar fruit taken directly from the tree, because of rubbing in handling.

OLERICULTURE

Cultural studies.—Cultivation studies with vegetables, made on Long Island by the New York (Cornell) station and supplementing earlier work at Ithaca, again showed that the principal benefit from tillage is in suppression of weeds. Only in the case of cabbage did cultivation increase yields appreciably. Deep tillage was deemed actually harmful since it destroys the feeding roots in the upper soil zone.

Corroborating findings of certain other stations, the Iowa station observed that clay pots are superior to composition pots, paper bands, and box flats for growing young vegetable plants. However, growth made by plants in the substitute containers, watered with a dilute solution of nitrogen fertilizer, practically equaled that made by plants in clay pots.

Maturation changes. — The chemical changes associated with quality in canning peas were found by the New York State station to include an increase in the calcium content of the seed coat as ripening progressed. Such changes as increases in dry matter, starch, and in the protein-nonprotein ratio, observed in the ovules in the course of ripening, could be measured by mechanical means, such as resistance to crushing. Applications of potassic fertilizers tended to decrease toughness, while the use of certain calcium materials had the opposite effect. The Maryland station

found that, concurrent with the rapid growth of summer squash, there was a marked increase in free reducing substances, with no well-defined changes in sucrose, starch, or acid hydrolyzable substances. Edibility was apparently limited by the hardening of the rind rather than by changes in composition.

Satisfactory development of the cauliflower head was found by the New Jersey stations to be related to the composition of the plant, and this in turn to the nutrient supply in the soil. Plants grown with a limited supply of nitrogen headed prematurely, whereas those supplied with enough available nitrogen formed desirable heads. There was more carbohydrate in all parts of the nitrogen-starved plants and more assimilated nitrogen in all parts of the plants supplied with nitrogen. Premature heading was induced by limiting the nitrogen supply in the nutrient solutions.

Vegetable breeding.—Studying inheritance in the garden bean, the Minnesota station found that stringlessness was apparently controlled by a single factor in some parental combinations, and by two factors in others. Pod width was found inherited as a quantitative character and apparently associated with a series of multiple factors. Pod color in the Crystal White wax variety gave monohybrid results when crossed with green, but when crossed with a yellow-podded variety dihybrid inheritance was indicated. In breeding greenhouse tomatoes resistant to Fusarium wilt, the Illinois station obtained two seedlings good enough to be named.

Working with the eggplant, the Oklahoma station found that the amount of flower dropping paralleled in general the amount of flowering and was little influenced by seasonal temperature. In varieties normally bearing one blossom per inflorescence the percentage of aborting flowers was very small.

Dealing with the resistance of the onion to smudge disease (*Colletotrichum circinans*), the Wisconsin station isolated two genes each capable of producing protocatechuic acid, a water-soluble chemical extremely toxic to the smudge organism.

Miscellaneous studies.—A storage temperature of 50° F. for keeping tomatoes, either green ripe or red ripe, was found by the Iowa station to be more satisfactory than 36° or 70°. At 36° full-ripe tomatoes soon lost their original attractive color, while at 70° the loss in weight and acidity was very rapid.

Dried sweet-corn kernels were found by the Iowa station to absorb distilled water more rapidly and in greater quantity than did dent corn. Stowell Evergreen kernels increased 113+ per cent in weight, as compared with 73+ per cent for dent corn.

The onion was found by the Utah station to grow well over a rather wide range of soil reaction, pH 5.5 to pH 7, and to be only slightly affected by changes in environment, such as temperature and light.

A comparatively rapid and accurate method of determining the solidity of cabbage heads, based on the buoyancy of the head when inclosed in a rubber cloth, was developed by the California station, and promised to be useful to cabbage breeders.

FLORICULTURE

Cultural treatments.—Control of the length of day was found by the Ohio station to be an effective means of influencing date of blooming of chrysanthemums. Curtailing the daylight by four hours caused plants to blossom from 22 to 56 days earlier than the controls, and stem length was shortened, although not enough to render the flowers unmarketable. Reductions in daylight greater than four hours did not further hasten blooming. Subjecting young chrysanthemum plants to a hardening treatment involving a decrease of water, at the Michigan station, failed to influence the size of bloom, length of stem, or date of flowering.

Nutrient studies.—Most species of flowers were found in Ohio station studies to grow satisfactorily under a rather wide range of soil reaction, although usually a slightly acid reaction was preferred. Extremes in either direction were harmful, and growth of many species apparently was depressed near the neutral point, pH 7. Aluminum sulphate and various forms of lime were found effective as acidifying and alkalinity-promoting agents, respectively. Some indication was observed at the University of Illinois that the water used on greenhouse plants may be harmful if overcharged with chemicals. Petunia, phlox, and zinnia seedlings were injured by water containing chlorine in excess of 5 parts per million. Zinnias were slightly injured by water containing 200 parts per million of common salt. A mixture of sodium chloride and sodium sulphate was less harmful than either material used alone.

Forcing gladioli.—Attempts to hasten the blooming of gladiolus corms were only partially successful at the Illinois station. Prolonging the day had some hastening influence, but the process proved rather costly for general use. Certain chemicals, as ethylene dichloride and ethylene chlorohydrin, hastened blooming to some extent. Low storage temperature delayed blooming and high temperatures tended to reduce the percentage of bloom. A temperature of 40°–45° F. in early storage followed by a short preplanting exposure at 70° is deemed most desirable.

J. W. WELLINGTON.

PLANT DISEASES

During the past year the stations made progress in several important lines of research on plant diseases, especially on smut, rust, and other diseases of cereals, canker and blight of fruit trees, wilts of vegetables, virus diseases of potatoes, tobacco, and other crops, and cotton root rot. Important contributions were also made to the information on disease resistance and insect carriers of plant diseases.

Further evidence that there exist strains of the same disease organism having different degrees of virulence was reported by several stations. The Oregon station reported finding at least 10 distinct forms of the organism causing bunt in wheat, the Minnesota station reported 10 different forms of fusarial disease of cereals, and other stations reported a similar condition in these and other diseases. This situation greatly complicates the problem of developing disease-resistant crops. However, progress is being made by the stations in securing varieties or strains of crops that are considered sufficiently resistant to be of practical value in reducing losses from disease. For example, the Indiana station has found varieties of wheat that are resistant to two strains of leaf rust, and the Nebraska station has developed strains of red winter (Turkey) wheat that appear to have a high degree of resistance to both stinking smut (bunt) and black stem rust. Two wilt-resistant strains of forcing tomatoes (Blair Forcing and Lloyd Forcing) developed by the Illinois station were reported to be giving excellent results. Wilt-resistant strains of tomatoes were also reported by the Michigan station. The New York State station has secured from a cross of Newman and Herbert raspberries seedlings that show outstanding resistance to mosaic.

In further study of root rot of cotton, the Texas station found that the causal organism may survive for 30 months in fallowed soil, thus showing the need of growing nonsusceptible plants for long periods in rotation with cotton as a means of controlling the disease. Over 600 species of economic and native plants were found to be susceptible to the disease, indicating the necessity for keeping the rotation free from weeds during the growth of the nonsusceptible plants.

As a means of controlling virus diseases of potatoes and to secure disease-free seed, the New York (Cornell) and Oregon stations found the tuber-unit method of roguing to be more effective than mass roguing.

Further evidence that insects play an important part in the dissemination of plant diseases was furnished by work of the Nebraska and Washington stations on virus diseases of potatoes and beets, respectively, and of the Arkansas station on fire blight of apples and pears.

Cereal diseases.—Inoculation studies at the Indiana station upon 734 varieties of wheat showed only 53 to possess resistance to the two physiologic forms of leaf rust utilized. A few varieties, notably Warden, Vernal emmer, Acme, and Buford displayed resistance to all forms of rust available for study. The resistance of emmer and rye was transferred by breeding to bread-wheat types. The resistance of corn to rust was found to rest in a simple dominant character, the factor for which was not linked with that of any of a number of other characters studied. Excessive nitrogen increased the susceptibility of wheat to leaf rust, whereas phosphorus and potassium used singly or in combination decreased susceptibility.

Oat varieties were found by the Michigan station to differ markedly in their resistance to smut, the Markton oat being practically immune and the Anthony highly susceptible. Stem rust of oats was particularly harmful to the Silvermine, Markton, Wolverine, and Swedish Select varieties, and caused little injury to Richland and Iogold, early-maturing varieties.

Certain strains of hard red winter wheat selected from the Turkey variety by the Nebraska station for resistance to stinking smut were found also resistant to black stem rust, and a few lines displayed strong resistance to low temperature injury. Differences observed in the response of the new Turkey selection to inoculation by various forms of bunt suggested the

presence of both mild and virulent physiologic forms of the disease.

In attempting to develop barleys resistant to scab, the Wisconsin station found that varieties differed widely in their resistance, and that no barley possessed resistance in any degree equal to that displayed by wheats. *Tilletia foetens* was found by the Michigan station to be the principal cause of stinking smut. Formaldehyde, organic mercury dusts, and copper carbonate were about equally effective in control, but because they cause less injury, the dusts are conceded to be the safer remedies, especially for wheat.

At least 10 forms of bunt, 6 belonging to *Tilletia levis* and 4 to *T. tritici*, were found by the Oregon station to cause injury to wheat. Important wheat varieties such as Martin, White Odessa Alvit, Regal, Hussar, and Ridit were found susceptible to one or more forms of bunt, suggesting that inheritance studies should deal with specific forms of the disease and with pure lines of wheat. Pure lines of bunt differing in their virulency were developed by selecting single diseased heads.

In a comparative study of 10 different forms of Fusaria attacking cereals, evidence was found at the Minnesota station that various physiologic forms of the several Fusaria can be distinguished by their parasitism on cereal varieties.

Fruit diseases.—Attempts at the Florida station to control bark diseases of citrus trees by scraping and disinfecting the diseased areas gave good success in the case of infections of recent origin, whereas old wounds were difficult and often impossible to cure. Citrus-canker studies showed that a saturated solution of potassium permanganate used in a strength of 1–100 would kill cultures of the organism in 2.5 minutes, but in sterilized sandy soil which had been subsequently inoculated with the bacteria, control with potassium permanganate was difficult. All of 61 forms of Rutaceae inoculated with the canker organism developed lesions and certain nonrutaceous plants were found to harbor the organism for some time, although no lesions developed.

Definite differences between crown gall, hairy root, and callus overgrowth were found in studies by the Wisconsin station. It was observed that the pathogenes gained entrance through wounds, but not readily through callus tissues, and it is surmised that insects feeding on the roots or graft callus permit the entry of diseases although no disease spores were found in insects.

All commercial varieties of peaches were found by the North Carolina station to be susceptible to bacteriosis, *Bacterium pruni*, with some indication of gradations in susceptibility. The cankers were often so numerous on the peach and plum that only drastic pruning would remove them all. Attempts to develop a successful spray control were not successful, though certain materials such as colloidal sulphur, potassium permanganate, and emulsified cresol did often reduce infection. The Illinois station found that a spray consisting of zinc sulphate and lime and combinations of this with other materials gave some measure of control of the disease. The bacterial spot was particularly injurious to Elberta and J. H. Hale peaches, practically eliminating the latter as a commercial variety.

Soggy breakdown occurring in Grimes Golden and Wealthy apples stored at 30° and 32° F. was found by the Iowa station to be controllable by holding the fruit at 50° for six weeks prior to storing, but as scald was increased by this procedure, no definite recommendations were made.

In further studies on the development of pears resistant to fire blight, the Oregon station found that in certain lines resistance was transmitted to a high degree through the seed, and that certain resistant types although of little value per se, were promising as rootstocks and trunks for better varieties. At the Tennessee station, *Pyrus calleryana* and *P. betulaefolia* showed resistance, not only to fire blight, but also to a leaf spot which practically defoliated many pears by midsummer.

An extremely severe outbreak of fire blight occurring in 1930 in susceptible varieties of apple was found at the Arkansas station to be confined largely to the blossoms, with an indication that blossom-visiting insects were responsible. Pears were not severely affected, nor could any connection between the presence of pear trees and outbreaks of blight in apple orchards be traced. The New York (Cornell) station found cultivated roses, hawthorn (*Crataegus oxyacantha*), Japanese quince, and *Photinia villosa* to be attacked by the fire-blight organism. The bacillus causing the disease survived in an acid medium of pH 4.6, and withstood freezing at —183° C. for 10 minutes, and heating to 48° for 10 minutes. Pathogenic bacteria obtained from infected limbs survived for

two years in the laboratory. The most common manner of entrance into blossoms was found to be through the nectariferous surfaces with occasional entrance through the petals and styles. The older the bloom when exposed the less the hazard of infection to fire blight, and pollination was found to have little or no influence on susceptibility.

Vegetable diseases.—Attempts by the California station to develop methods for controlling the powdery mildew of cantaloupes in the Imperial Valley were largely unsuccessful, but it was found that sanitary measures such as the destruction of the refuse of cucurbits and other susceptible plants were helpful. Of fungicides tested, sulphur dusts and sprays were injurious to the plants and Bordeaux mixture gave only partial control.

Some progress in the control of cucumber wilt on Long Island by controlling cucumber beetles, the known vectors, with arsenical dust and sprays was reported by the New York (Cornell) station.

Eggplant-wilt control by means of soil acidification was tested by the Massachusetts station, with the conclusion that the present plan of using fresh soil is the only reliable control. At the New Jersey stations the wilt was found more severe on limed than on unlimed soils. None of 55 lots of eggplant was found immune to wilt although some variation in susceptibility was noted. Eggplant fruit rot was found to be carried under the seed coat and the immersion of seed in hot water gave promising results.

Favorable results in potota-scab control were secured by the New Jersey stations by adding to the fertilizer 15 pounds of mercurous chloride per acre. A total of 92.1 per cent of the tubers grown on the mercury-treated soil were free of scab as compared with 46.7 per cent on the control area. Rhizoctonia was reduced from 98.5 per cent on the control to 52 per cent on the treated plats.

Surface treatment of tomato seed with bichloride of mercury killed all organisms present, indicating that such diseases as Fusarium, Alternaria, and Verticillium are rarely carried within the seed. Mercuric chloride 1–1,000 for 10 minutes proved more effective than an organic mercury compound for the control of sweetpotato scurf.

Progress in the selection of Fusarium wilt-resistant strains of John Baer, Grand Rapids Forcing, and Nellist Ideal tomatoes, was reported by the Michigan station, and the Illinois station reported excellent results in developing wilt-resistant forcing tomatoes, two of which were named Blair Forcing and Lloyd Forcing. The Michigan station found that the organism *Phytomonas vignae*, causing the bacterial spot of Lima bean, overwinters in the soil.

Fusarium wilt of tomatoes was found by the Texas station to occur on soils differing widely in acidity, indicating a broad adaptability of the fungus, or the existence of several physiologic strains. Puffing of tomatoes, found to occur on many soils and under varied weather conditions, is deemed to be due to an inherent weakness in the plant rather than to pathogenes.

Cotton root rot.—In further study of cotton root rot the Texas station found viable sclerotia in great numbers to a depth of 2 feet in infested Houston black clay soils. These sclerotia in one instance survived 30 months of fallowing. Laboratory studies showed the most favorable temperature range for sclerotia production to be from 21° to 27° C., and that these bodies formed as freely in light as in darkness and that small percentages of these survived 58 days under water. On the other hand, infested soil was air dried for 51 days without killing the sclerotia. A total of 623 species of plants were found susceptible to the root-rot disease. The only satisfactory control consisted in a rotation of susceptible and nonsusceptible plants with the latter grown for at least three years. In general, cereals, grasses, and other monocotyledonous plants were found nonsusceptible.

Virus and related diseases.—The Oregon station, cooperating with the United States Department of Agriculture, found that Jimson weed, black nightshade, wild bittersweet, tomato, and pepper may harbor the virus of potato leaf roll, and that black nightshade and tomato may harbor the rugose mosaic disease of the potato. It was found that tuber-unit roguing of potatoes was more effective than the so-called mass roguing for controlling virus diseases.

Wide differences between varieties of raspberry in respect to resistance to mosaic diseases were noted by the New York State station. For example, seedlings from a Newman×Herbert cross were outstanding in their resistance to both yellow and red mosaic. Seasonal conditions partly controlled the extent of injury by mosaic.

The onion disease, yellow dwarf, was found by the Iowa station to be due to a filtrable virus and to be most effectively controlled by the use of disease-free sets.

Certain potato viruses withstood drying in diseased tissue for at least 16 days, and aging in the juices of diseased tomato and Jimson weed for 60 days, in experiments reported by the Indiana station. Tomato-mosaic suspensions stored without preservatives in a refrigerator, proved infectious after 6 to 20 months. The virus was not inactivated when the acidity was greatly increased, to pH 2.46. At pH 7.5 to 8.5, virulence was lost but was regained when an acid condition was restored.

Tobacco mosaic was found by the North Carolina station to survive the curing process in barns. Exposure of infected leaves to a temperature of 190.4° F for 19 hours did not completely destroy the virus. The passage of virus from the soil into the roots of tobacco is believed to take place through wounds caused by insects or cultural tools.

Spindle tuber and unmottled curly dwarf of potatoes were found by the Nebraska station to be transmitted by grasshoppers, flea beetles, tarnished plant bugs, and Colorado potato beetle larvae. Flea beetles transmitted spindle tuber, but not the unmottled curly dwarf, and the leaf hopper failed to transmit spindle tuber. In general, the percentage of infection increased with the number of insects present and the percentage of infection was increased with artificial inoculations by increasing the amount of inoculum. The treatment of potato seed pieces with organic mercury immediately after the pieces were cut, was effective in preventing infection.

Table beets infected with mosaic disease showed indefinite symptoms at 50° F. and very marked symptoms at 70° in studies reported by the Washington station. Infected plants matured almost a month earlier than healthy plants. The disease overwintered in mother beets and was spread to healthy stock by aphids, leading to the practical suggestion that new seedings be placed at least 300 feet from the mother-beet beds.

Evidence that the mosaic disease of the pepper may be transmitted through the seed was obtained at the New Jersey stations where seeds from healthy and from mosaic-infested plants yielded 3.2 and 25.4 per cent of mosaic progeny, respectively.

Temperature was found by the New Hampshire station to be an important factor in the development of the outward manifestations of potato mosaic, diseased plants displaying only mild or obscure symptoms at high temperatures.

Types of mosaic that remained undetected in the field were found by the New York (Cornell) station to become evident under controlled greenhouse conditions, thus adding to the effectiveness of the tuber-unit method of indexing seed stocks and suggesting the inadvisability of placing full reliance on field roguing.

New fungicides.—The Illinois station found flotation sulphur to be a satisfactory substitute for lime-sulphur in the control of apple scab. Lead arsenate used alone gave 50 per cent control, indicating considerable fungicidal value. An oil-sulphur combination was found equally as effective and more pleasant to use than lime-sulphur in the control of peach leaf curl. Wettable sulphur used at a minimum dilution of 6 pounds per 100 gallons of water checked brown rot. Certain oil-sulphur-lime dusts were found to possess better sticking qualities than the usual lime and sulphur dusts.

Copper fungicides, in experiments by the Florida station, gave much better control of downy mildew of cucurbits than did sulphur, which was in fact ineffective. In most instances, copper dust gave as good control as did copper sprays.

Chemical hydrated lime was found by the Virginia station to be an excellent form for use in the manufacture of Bordeaux mixture. Calcium monosulphide as a spray for apple scab gave excellent control and caused less burning of fruit and foliage than did lime-sulphur. As a substitute for calcium caseinate, the waste sulphite liquor from paper mills known variously as glutrin, bandarene liquid, etc., gave entirely satisfactory results.

J. W. Wellington.

ECONOMIC ENTOMOLOGY

A large part of the recent work of the experiment stations on economic insects has been devoted to study of the problems of controlling pests that continue to cause great losses, particularly the codling moth and the oriental fruit moth. Noteworthy progress was made with investigations on insect parasites of the fruit moth and on insect transmission of plant diseases.

The value of chemically treated bands as a supplementary control measure in combating the codling moth appears to have been established through work by a number of stations.

The possibility of practical control of the oriental fruit moth by bait traps used over a large area was indicated in experimental work by the Indiana station. The New Jersey stations found parasites to be effective in holding the oriental fruit moth in check, approximately one-half of all the larvae feeding in peach twigs during the past six years having been destroyed by them. In 1929 about 50 per cent of the eggs of this pest were parasitized during the crest of egg laying. The effective parasite of the larva of the moth has been introduced and is rapidly increasing in a number of States.

The plum curculio was satisfactorily controlled by the Illinois station with three to four properly timed sprays made up of 2 pounds of arsenate of lead to each 50 gallons of material, also with oil dusts applied for the oriental fruit moth.

A pyrethrum mosquito larvicide was used successfully by the New Jersey stations on waters where oil is objectionable. It gave a complete kill of the larvae and pupae without harming fish, waterfowl, or plant life, at an expense lower than that of fuel oil.

Studies of transmission of plant diseases by insects were reported by several experiment stations. The fireblight organism was found by the Arkansas station in beehives and on bees in early spring, indicating that bees may transmit the disease. The Wisconsin station found that aphids may play an important part in disseminating mosaic on tomatoes or from tomatoes to tobacco when the two plants are grown in close proximity. Aphids may spread leaf roll of potatoes very rapidly and widely, according to the New York State station. Leaf hoppers transmitted yellows disease to asters, celery, carrots, and parsley, in experiments reported by the California station.

Other plant diseases transmitted by insects include the soft bacterial rot of cabbage found by the Minnesota station to be spread through the cabbage maggot, and decay in seed-potato slices found by the Maine station to be induced by the seed-corn maggot.

Codling moth.—The station work with the codling moth continued to be aimed particularly at the discovery of effective substitutes for the arsenicals and of supplementary control measures. A considerable advance was made through the use of other sprays and dusts, chemically treated bands, and bait traps as control measures.

The use of chemically treated bands was found by the Indiana and Illinois stations to be a cheap and effective supplementary means of controlling the codling moth in commercial orchards. In Indiana bands treated with alpha-naphthol-oil led in effectiveness and attractiveness to the larvae and almost entirely prevented adult emergence. A commercial orchardist in Illinois banded 1,633 trees at a total cost of 4.5 cents per tree and caught an average of 164 worms under each band. Bands 2 inches wide caught an average of 77 worms; 3 inches, 244; and 4 inches wide, 644 worms.

Mature codling-moth larvae which entered chemically treated bands placed about the trunks of apple trees by the Pennsylvania station were largely destroyed. The bands maintained their effectiveness against overwintering larvae, so that in December, 1930, more than 90 per cent were dead. Over 95 per cent of the mature larvae on well-scraped trees found their way into these trap bands.

Scraping the bark of apple trees was found by the Delaware station to be highly efficacious as a supplemental measure for codling-moth control, but ineffective as a control for the oriental fruit moth.

Paper bands treated with different chemicals for control of the codling moth, in experiments reported by the Nebraska station, resulted in kills ranging from 15 to 96 per cent of the worms that crawled under the bands to hide.

With bait traps filled with a ferment the Missouri station caught large numbers of emerging moths each night in an orchard, indicating that such bait traps may prove a valuable aid in worm control. The peak of the bait-trap catch occurred about one week after the peak of moth emergence.

In testing various sirup baits and aromatic esters the New Mexico station found that sirup in water at the rate of 1 to 10 was more attractive to the codling moth than any of the 35 esters tested. The addition of 0.2 per cent sodium benzoate increased the attractiveness of the bait by retarding and lengthening fermentation.

The practical value of the codling-moth bait trap as an indicator for timing spray applications was demonstrated by the California station in

1929, a year of record infestation on the Pacific coast. Four sprays timed by the bait traps resulted in 6 per cent of wormy fruit, while from five to seven sprays without the use of bait traps gave from 35 to 75 per cent of wormy fruit.

In combating the codling moth, the Oregon station found that calcium arsenate gave as good control as did lead arsenate and that lightweight oils killed from 96 to 100 per cent of the eggs, when used in dilutions as low as 1 gallon of the emulsion per 100 gallons of spray.

Good results from the use of oil sprays and dusts, particularly oil dusts, are reported by the Illinois station. By such means the small commercial orchardist is enabled to produce clean fruit without an objectionable spray residue requiring the fruit to be washed.

The oil-lead arsenate combination was found by the Washington station to be very effective against the codling moth in that the oil kills from 80 to 95 per cent of the eggs and at the same time improves the spray coverage of the lead arsenate. The station concludes that the oil sprays should be applied at the height of the egg-laying period in both broods, but should not be used with lead arsenate after July 15 since late application of this combination makes cleaning of the fruit difficult. Oil and nicotine sulphate in combination were found as effective as lead arsenate (2–100) in preventing worm entry when used in cover sprays and decidedly more effective in preventing stings.

The thermal constant was successfully applied by the New Jersey stations in determining when cover spraying should start for the first and for the second broods of codling moth. It is considered probable that the thermal constant can be used as a practical index of the length of periods during which spray coatings must be maintained on fruit and foliage to prevent entry by larvae of the first and of the second broods.

Seeking a substitute for lead arsenate, the New Jersey stations found that when a sufficient coating of nicotine tannate is maintained upon the foliage during the period of codling-moth activity, it controls the codling moth as well as lead arsenate and does not injure either fruit or foliage. Its adhesive qualities must be improved, however, before it can be classed as an efficient arsenical substitute.

Oriental fruit moth.—Progress was made in finding more efficient methods of controlling the oriental fruit moth, particularly in using the parasites of the larvae.

Where late varieties of peaches were grown with early varieties, the Pennsylvania station found that the majority of the moths migrated in the fall to the late varieties where the greatest percentage of hibernation took place. As a result the highest initial infestation in the spring occurred in the late varieties from which the moths spread to the other varieties in the orchard.

White oil-pyrethrum spray was found by the New Jersey stations to be more effective in killing newly hatched oriental fruit moth larvae on new growth of peach twigs than on old. This was apparently due to the old growth's greater absorptive power for the oil. A 0.5 to 1 per cent white oil-pyrethrum spray on a 5-day schedule against third-brood eggs and larvae resulted in a reduction in invisible fruit infestation of from 60 to 70 per cent.

The possibility of a practical commercial control of the oriental fruit moth with bait traps used over a large area was indicated in experiments by the Indiana station and United States Department of Agriculture cooperating.

Parasites of the oriental fruit moth were studied by a number of stations. Over 40 different species of native insects were found by the New Jersey stations to parasitize the moth. The stations observed that a season of heavy infestation is followed by one or more seasons of comparatively light fruit infestation, such reductions being attributed in large measure to the work of parasites. The largest number and the most important of the parasites attack the larvae in the twigs, although the other stages have their enemies. The station reported that approximately one-half of all the larvae feeding in peach twigs during the past six years were destroyed by parasites.

Macrocentrus ancylivora and *Glypta rufiscutellaris* were found to be parasites of major importance in New Jersey, the former being especially effective on twig-feeding larvae in southern New Jersey. In northern New Jersey *G. rufiscutellaris* was almost equally effective from 1925 through 1927, but has been replaced in importance by *M. delicatus* and *Pristomerus ocellatus*. Life-history studies by the New Jersey stations have shown that *M. delicatus* and *M. ancylivora* are two distinct species. *M. ancylivora* may be introduced to advantage in sections where

it is slow to build up or where it is not present naturally. While parasites have been particularly effective in holding down the peach moth in certain sections over a period of years they can not be depended upon year after year to keep the moth under control.

Investigations on parisitization of the oriental fruit moth with *M. ancylivora* were reported by the Delaware, New York State, and Illinois stations, investigations with *M. delicatus* by the Ohio station, and investigations with *Trichogramma minutum* by the New York State and New Jersey stations.

Refrigeration was found by the Connecticut State station to affect strongly the ratio of males and females of the egg parasite of the oriental fruit moth, 25 per cent of males emerging after 12 days of refrigeration and 75 per cent after 50 days.

Other fruit insects.—The Michigan station reported that the fruit-tree leaf roller, a major pest of apples and pears in the State, has been controlled to the extent of 98 per cent by the use of emulsions made from a paraffin oil emulsified with a commercial form of calcium caseinate, applied at a strength of 6 per cent.

In control of the apple aphid the Ohio station found potassium oleate, sodium oleate, and an oxidized mineral oil to be quite efficient in increasing the toxicity of nicotine. Sodium oleate and the oxidized oil were found to be the most effective in 0.5 per cent dilutions.

The woolly apple aphid parasite, *Aphelinus mali*, introduced into Oregon from Michigan in 1928 by the Oregon station, survived two winters in the field and spread rapidly from the points of liberation.

Larvae of the leopard moth were killed by the New Jersey stations with soluble pine oil in which naphthalene had been dissolved, applied thoroughly to the twigs and branches of the apple at temperatures such as obtain in the spring before the buds begin to swell.

For control of the San Jose scale the Washington station found oils ranging from 50 to 85 in sulphonation test to give good results when applied in a 4 per cent emulsion during the dormant season.

Injury of the bean thrips to pears was reduced by the California station by spraying with a 2 per cent light oil and one-half pint of 40 per cent nicotine sulphate to 100 gallons of water, and by using fine dusting sulphur applied at the rate of about 15 to 20 pounds per acre.

For control of the Pacific coast mite on grapes the California station found very finely ground sulphur dust applied thoroughly to both surfaces of the leaves to be very effective. The application of a 1 per cent summer oil emulsion was found by the Illinois station to be a promising method of controlling mites on small fruits at a reasonable cost. Four applications at 21-day intervals, commencing May 1, of an emulsion containing an 83-viscosity white oil at 1 per cent concentration gave very satisfactory control.

The plum curculio was controlled successfully, in experiments by the Illinois station, with the oil dusts applied for the oriental fruit moth. Three to four properly timed sprays made up of 2 pounds of arsenate of lead in each 50 gallons of spray material gave satisfactory results.

The mealy plum aphid was successfully combated by the California station with a highly refined oil of a 2 per cent strength applied three times from March 16 to April 4.

The destructive prune worm (*Mineola scitulella*) was effectively controlled by the Idaho station with nicotine sulphate.

The cherry case-bearer was controlled successfully by the Wisconsin station with a paraffin-oil spray. From 80 to 98 per cent of the insects were killed by this treatment. Light traps gave some promise—one trap catching over 9,000 moths, many of which were heavy with eggs, in a single night.

A 75 per cent reduction in numbers of the grape leaf hopper was obtained by the Delaware station by applying on June 13 a 40 per cent nicotine sulphate at a 1 to 800 dilution in combination with Bordeaux mixture 6–12–100 and 3 pounds of dry arsenate of lead.

For controlling the strawberry root weevil and the rough strawberry root weevil the Oregon station used, with good results, a bran bait which can be made up easily and cheaply.

For combating the black-headed fireworm of the cranberry the Washington station found nicotine sulphate with soap or oil to be more effective than pyrethrum. Many of the larvae were killed by a 1 to 400 nicotine spray even in the webbed condition, if the temperature was 70° F. or higher. At 60° or lower pyrethrum sprays were found more satisfactory than the nicotine.

Perfect control of the citrophilus mealybug as a result of the introduction from Australia of two chalcidoid parasites, *Coccophagus gurneyi* and

Tetracnemus pretiosus, was reported by the California citrus station.

In tests of the egg parasite *Trichogramma minutum* for controlling the orange tortrix a high percentage of parasitism was obtained by the California citrus station from liberations made on two heavily infested orange trees.

Nut insects.—The walnut husk fly, a new pest in California, was effectively kept under control by the California citrus station with basic lead arsenate as a spray or dust.

Pecan nut case bearer infestation was greatly reduced by the Texas station with a single application on May 8 of lead arsenate at the rate of 3 pounds to 50 gallons of water.

Vegetable crop insects.—Sodium, barium, and calcium fluosilicate were used successfully by the California station to kill larvae of the vegetable weevil.

The flea beetle on tobacco was kept under fair control with cryolite and barium fluosilicate without injury to the foliage, in experiments reported by the Connecticut State station.

With the bean jassid, the Florida station found that pyrethrum sprays gave consistently greater immediate kills and showed more lasting effects than nicotine-sulphate sprays used in connection with Bordeaux mixture, with soaps, or with the new activators which are effective against aphids.

The onion maggot was effectively controlled by the Ohio station with a 2 per cent lubricating-oil emulsion combined with a 4–6–50 Bordeaux and applied at the rate of 150 gallons per acre under 20 pounds pressure.

In experiments with the onion thrips at the Illinois station, nicotine sprays were made more deadly by the addition of a commercial oxidized oil as an activator for the nicotine. The addition of a small quantity of oil also increased the adhesiveness and killing power of nicotine dust.

Poison bran mash used in combating the grasshopper did not seriously affect birds that fed upon it or that devoured insects eating it, in experiments reported by the Oklahoma station.

Field-crop insects.—The Michigan station found it possible to destroy all corn borers in corn fodder by putting the fodder through a husker-shredder adjusted to cut it shorter than 1 inch. Borers buried from 4 to 16 inches deep by plowing or by other means came to the surface.

Further study of strains of corn showing resistance or tolerance to the borer was reported by the Illinois station.

In experiments on the corn ear worm, the California station found sodium fluosilicate consistently superior to other materials tested, one treatment at 70 per cent strength applied to the ear in the silk stage proving fairly effective. The Maryland station found lead arsenate to be the most efficient of the insecticides employed against the corn ear worm.

In dusting experiments with the three-cornered alfalfa hopper, the Alabama station found sodium fluosilicate more effective than nicotine, sulphur, or paradichlorobenzene.

In tests of dusts for the cotton flea hopper, the Texas station increased the yield of cotton 36 per cent as a result of four applications of sulphur in May and June. The dust was successfully applied on one farm by airplane.

Ornamental plant and other insects.—The greenhouse leaf tier was controlled effectively by the Illinois station with a sulphur-lead arsenate dust at 25 per cent of the cost of old methods of control. The egg parasite *Trichogramma minutum* was also found to be of considerable value in bringing a heavy infestation under control.

The 2-spotted mite attacking the ornamental asparagus in ferneries was controlled by the Florida station by thoroughly wetting the plants at 7-day intervals with a 1-to-100 solution of white oil emulsion. Solutions of a derris compound also were effective, but white oils are much cheaper.

The iris borer was controlled successfully by the Michigan station by applying a solution of corrosive sublimate, 1 ounce to 8 gallons of water.

White grubs in lawns and flower gardens were controlled by the Ohio station with a solution of 8 or 10 ounces of sodium cyanide in 50 gallons of water, sprinkled over the infested area at the rate of 2.5 gallons per square yard. To avoid injury this solution should be thoroughly washed off the plants one or two hours after its application.

Other insect pests.—The European pine shoot moth was controlled by the New Jersey stations by spraying infested trees during June with an oxidized mineral oil diluted 1 to 200, plus 40 per cent nicotine sulphate 1 to 500. Three sprays applied at intervals of from 7 to 10 days killed the adults

125057—32——4

hiding in the trees and the eggs laid upon the terminal twigs.

In a study of stored-product insects, the New Jersey stations observed that certain insects subjected to high-frequency radio waves were killed by the internal temperature so induced.

Pyrethrum mosquito larvicide, the New Jersey stations found, can be safely used on breeding waters where oil is objectionable. When properly diluted it gives a complete kill of larvae and pupae, is harmless to fish, waterfowl, and plant life, can be prepared readily, and is cheaper than fuel oil.

Eggs of the mosquito *Aedes vexans* collected by the Montana station in 1928 and stored in sealed glass vials in a refrigerator hatched readily in 1930 when placed at a higher temperature. Eggs allowed to dry out until shriveled hatched when placed in water. Prolonged exposure to a subzero temperature apparently had no detrimental effect.

Insecticides.—The advantages of fluorine compounds over lead arsenate, as shown by the Tennessee station, are that they can be used in the dust form more effectively than sprays, are not noticeably injurious to foliage, and leave a comparatively harmless residue.

A bran and sodium fluosilicate mash was used effectively by the Oregon station to control the decorated strawberry root weevil.

A mixture of hydrated ferric oxide with lead arsenate was found by the New Jersey stations to increase the adhesive properties of the insecticide on apple foliage and to prevent arsenical injury.

Dormant oil sprays may not be applied safely to apple trees in the spring before bud scales begin to separate, according to the Idaho station. Oil of 50 to 70 sulphonation and of not less than 100 viscosity test may be used safely for dormant spraying. Oil in combination with lead arsenate was found to increase materially the degree of codling-moth control. Oils of not less than 85 sulphonation and 65 to 75 viscosity test proved satisfactory for foliage sprays.

In a study of the penetration and injury of plant tissue by petroleum oils, the New Jersey stations found that all the oils tested penetrated through the under surface of the leaf, presumably through the stomata, at rates varying inversely with their viscosities. Only oils of low viscosity caused injury by penetrating through the upper surface of the leaves. The penetration of emulsified oils was much slower and was accompanied with less injury than that of pure oils. Only oils of very low viscosities penetrated through the cork and into the cambium of the apple twig.

In experiments with summer oil sprays, the New Jersey stations showed that peach trees are less susceptible to oil injury than are apple trees and that continuous oil spraying of apple trees during the growing season may bring about physiological changes in growth processes and fruit production. Oil injury from sprays applied during May and June was more pronounced than from late sprays applied during July and August. Sperm oil proved less injurious to peach and apple foliage than any of the animal and vegetable oils tested.

A method for determining the quantity of oil retained by citrus foliage, devised by the Alabama station, showed that in general retention increased with viscosity but not proportionately.

Insect transmission of plant disease.—The Arkansas station found the causative organism of fire blight in beehives and on bees in the early spring prior to the development of blight, indicating that bees may disseminate the disease.

That aphids probably do not disseminate ordinary tobacco mosaic from diseased to healthy tobacco plants is the conclusion from cooperative experiments by the Wisconsin station and the United States Department of Agriculture. They may, however, play an important part in the dissemination of the disease on tomatoes or from tomato to tobacco where these crops are grown in close proximity. The New York State station found that aphids feeding on sprouts of seed potatoes spread leaf roll very rapidly and widely if they are numerous.

In studies of transmission of yellows disease by the 6-spotted leaf hopper, the California station found that White Belgian and Short White carrots and Hamburg parsley were naturally infected with the virus. Noninfected leaf hoppers feeding on plants infected experimentally became infective and transmitted the disease to healthy asters and celery. The disease was then transmitted from infected asters and celery back to carrots and parsley, and also transmitted from infected carrots to healthy carrots, and similarly from parsley to parsley, carrot to parsley, and parsley to carrot.

The cabbage maggot and closely related species, the Minnesota station found, may spread soft rot bacteria of cabbage and other Cruciferae.

Evidence that the cabbage maggot is a carrier of rot of turnips and Chinese cabbage in the field and in storage, and that the seed-corn maggot may be associated in a similar way with decay of potatoes, was reported by the Maine station.

WILLIAM A. HOOKER.

ANIMAL PRODUCTION

Investigations in animal production by the experiment stations cover a wide range of scientific and practical problems in breeding, feeding, and management of livestock. Much of the work is of a kind that gives results having immediate practical application, but an increasing amount of attention is being given to the fundamental investigations needed to solve the more complex problems that constantly arise. Research of this nature usually requires a long time for its completion to a stage where the results may be applied in practice.

The following are a few of the many results of recent station work in animal production which appear to have special significance and value.

Anemia, which develops especially where adequate pasture is not available, causes large losses in young pigs. The Illinois, Indiana, New York (Cornell), and Wisconsin stations found that it can be prevented by brushing the sows' udders with solutions of copper and iron salts, or in other ways insuring the consumption of small quantities of these salts by the young pigs. Pigs allowed access to pasture did not contract the trouble. Presumably they picked up sufficient amounts of the minerals from the soil.

Opinions as to the influence of sex on the quality of meat differ. In studies on the relative quality of steer and heifer beef, the Nebraska, Missouri, and Illinois stations, cooperating with the department, showed quite conclusively that the meat did not differ except that heifer carcasses were a little more wasty owing to the larger proportions of fat carried by heifers of all ages, which finished more rapidly than steers.

Although it is a common belief that exercising the animals has an unfavorable effect on the quality of meat, the Illinois station found no difference in the dressing percentage, color of lean, firmness of fat, toughness, or chemical composition of beef from steers exercised on a treadmill as compared with beef from similar steers not specially exercised.

With wheat at a relatively low price the possibilities of using wheat as a basic grain ration are interesting. Whole wheat proved practically as palatable as shelled corn for fattening lambs at the Nebraska station, and was 87 per cent as efficient as corn in producing gains. A mixture of whole wheat and shelled corn in equal parts produced gains as economical as those made on shelled corn alone.

Cottonseed meal was fed in large quantities to dairy calves and heifers at the Michigan and Oklahoma stations without apparent harmful effects. Rations of cottonseed meal, cottonseed hulls, yellow corn, stover, and gluten were used by the North Carolina station with satisfactory results. Several other stations used cottonseed meal successfully in swine rations. These results showed the increased possibilities of utilizing this relatively cheap source of protein. On the other hand, a deleterious effect on the quality of stored eggs from hens fed cottonseed meal was brought out in studies at the Mississippi and Oklahoma stations.

That an adequate supply of calcium and its proper assimilation is essential for both growth and egg production in poultry has been demonstrated by the Ohio, Kentucky, and New Jersey stations, which found that oyster shells and limestone were efficient sources of calcium for growth. The New York (Cornell), Kentucky, and Wisconsin stations showed that, in addition to an adequate supply of calcium, a sufficient amount of the antirachitic vitamin, either from sunlight or some other source, is necessary for normal growth and egg production.

Station work from which the above and other significant conclusions are drawn is reviewed in the following pages.

Nutrition.—Certain of the mineral supplements commonly fed to livestock contain fluorine, about the function of which in animal nutrition little is known.

The Illinois station found that either calcium or sodium fluoride when fed to rats inhibited growth. When fed at rather high levels sodium fluoride appeared to lower feed consumption, while calcium and sodium fluoride lowered the percentage of calcium retained. Fluorine in the form of soluble sodium salt caused abnormal bone formation, and both calcium and sodium fluoride brought about a characteristic abnormality of the teeth.

Mineral supplements containing 2 per cent or more of fluorine apparently depressed food consumption and growth

of swine at the Illinois station, and at 3 per cent or higher levels were distinctly toxic. Feeding fluorine compounds even at high levels did not affect calcium utilization, although there were indications that the high levels had a depressing effect on calcium metabolism.

Similar results were obtained at the Ohio station in feeding sodium fluoride to swine. Rock phosphate, which contains fluorine, affected the bones and teeth in a similar manner. Sows farrowed apparently normal full-time pigs when either sodium fluoride or rock phosphate was fed, but with rock phosphate difficulty was experienced in getting sows to consume enough feed to properly nourish their young. The station concluded that rock phosphate should furnish only one-third or less of the calcium requirements of pigs if bad effects are to be avoided.

Molasses is often fed in fattening livestock, with beneficial results. Cane molasses used by the Ohio station as a supplement to a whole-milk diet for rats produced excellent growth and prevented anemia, or, when fed after anemia had developed, had a curative effect. On the other hand, beet molasses retarded growth and did not prevent nutritional anemia nor benefit rats suffering therefrom. Chemical analysis showed that cane molasses contained more iron and copper than beet molasses. Both cane and beet molasses were found by the Iowa and Minnesota stations to stimulate the appetite and increase the feed consumption of fattening cattle. It also appeared that both molasses contained some substance which played an important rôle in long-time feeding tests with calves. The benefits derived from including a limited quantity of molasses in fattening rations were thus at least partially explained.

Studying the losses of nutrients in hay caused by leaching, the California station found that in certain forage plants these varied from 25 to 67 per cent in that portion of the mineral matter available to animals. In legumes the losses of calcium were insignificant, but greater in grasses. Leaching distinctly lowered the percentage of phosphorus in all plants. Crude protein was materially reduced in naturally cured samples, and the loss of sugars, which are easily digested, was considerable. These changes resulted in an increase in crude fiber, which may decrease the digestibility of the other constituents besides being itself difficult to digest.

Physiology of reproduction.—Increased attention is being given to the study of the physiology of the reproductive cycle in domestic animals and the fundamental causes of the physiological changes associated with reproduction. It has been found that during pregnancy a substance termed a hormone is secreted in the urine and causes maturation of the genital organs and ovulation in immature female rats used as test animals. The presence of this substance may serve as an early test for pregnancy in domestic animals. The California station found that blood serum from nonpregnant mares did not affect growth in the ovaries and other genital organs of immature rats, but as pregnancy advanced the serum stimulated ovarian growth, reaching a maximum at about the eightieth day of pregnancy. It appeared that the presence of the hormone in the blood stream of pregnant mares might be used to diagnose pregnancy at from six to seven weeks. In similar studies of the hormone content of the urine of cattle during pregnancy, the Missouri station found that dairy cattle showed a noticeably higher level of secretion after 100 days of gestation, and beef cattle after 180 days.

In a study of the function of the ovary in maintaining pregnancy in rats, the Iowa station found that when ovaries from immature females or from females not in heat were grafted into pregnant females, pregnancy usually proceeded to full term; but when the rats furnishing the grafts were in heat, abortion or death of the fetuses usually occurred. The removal of ovaries from pregnant females was usually followed within two days by abortion. It appeared that the luteal tissue normally developing in the ovary following the production of the female germ cell is essential for the maintenance of normal pregnancy.

Injection of an extract of the pituitary gland into cows after the evening milking was found by the Missouri station to increase the fat content of the milk and to cause a more complete discharge of the milk already in the udder, but apparently had little effect on the actual stimulation of milk production. The subsequent effect, possibly the result of a contraction of the blood vessels, appeared to be to inhibit milk secretion.

The duration of the heat period in gilts was found by the Missouri station to be from 40 to 46 hours, but after the first litters were born the

periods lasted about 65 hours. There was an interval of 21 to 22 days between the onset of successive heat periods. By breeding sows at different times during the heat period it appeared that the middle portions of the heat period were more nearly optimum than when the sows showed the first or last signs of heat.

Beef cattle.—Investigations with beef cattle covered a wide range of problems dealing especially with management and feeding. Cottonseed cake as a supplement was profitably fed by the New Mexico station to beef cows on the range when the calves were to be marketed in the spring. For calves to be marketed in the spring 1 pound of cottonseed cake per day was the most economical ration, but when the calves were to be held until the next fall not more than 0.5 pound was more economical. Although feeding a small quantity of cake had little effect on the weight of a cow or of her calf at birth, it produced more rapid gains in the calves. Minimum quantities of cake were most efficient for production and did not materially reduce summer gains. Heavy cake feeding during the winter, however, reduced the gain on grass alone during the following summer.

Steers fed grainless corn silage at the Tennessee station made slower gains and had a poorer finish than those fed normal silage. Removing the ears of corn in the field reduced the yield of silage and the value of the pulled corn.

Steer calves full-fed in dry lot until finished for market were more profitable in experiments at the Iowa station than either yearlings or 2-year-olds. While calves took longer to fatten, they needed less feed per 100 pounds of gain. Yearling steers were slightly more profitable than 2-year-old steers. The 2-year-olds made greater gains than the calves or yearlings during the finishing period, but required more feed per unit of gain and sold at a lower price.

Sorghum produced over twice as much silage per acre as corn, in experiments at the Mississippi station, and proved more certain on thin lands and under variable rainfall conditions, while sagrain, yielding about 25 per cent more silage than corn, was particularly adapted to certain sections of the Delta. For finishing steers corn silage was more valuable pound for pound than either sorghum or sagrain, but none of the three silages equaled cottonseed hulls.

Substitution of sweetclover hay for alfalfa in a fattening ration for aged steers gave fairly satisfactory results at the Minnesota station, although the alfalfa hay was more palatable, and under similar conditions cattle consumed more of it and made larger gains than those on sweetclover.

Adding a small quantity of cottonseed meal to a wheat-straw ration was found by the New Mexico station to increase the consumption of roughage. Steers fed wheat straw only showed a negative nitrogen balance; adding 0.5 pound of cottonseed meal caused the nitrogen balance to be positive, and also increased the rate of gain. The added proteins were almost solely responsible for the increase in the total digestible nutrients in the ration. As the quantities of total digestible nutrients in the ration were increased, the pulse rate of the steers increased, suggesting that pulse rates may be indicative of metabolic intensities of animals.

Breeding beef heifers to calve at 2 years of age reduced the percentage of calves produced by the same cows when 3 and 4 years old, but not when 5 and 6 years old, in Oregon station experiments. The birth weight of calves and the rate of gain to weaning time apparently increased with age of dam up to at least 5 years. The size of calf produced in subsequent years was not affected by early breeding of the dam.

Studies by the Iowa station on the inheritance of color in blue-gray cattle from a Galloway-Shorthorn cross indicated that the recessive whites produced breed true. The presence of pigment in the ears showed dominance over the almost complete lack of pigment in this region. Matings of white cattle with dark points to an Ayrshire bull with only a few red markings produced blue-gray offspring only, indicating that the two types of white differ genetically.

Sheep.—To determine what constituted a typical Hampshire carcass and fleece and the points emphasized most in show-ring selection, the Wyoming station measured, photographed, and took wool samples from all lambs and yearlings winning premiums in the individual classes at the 1930 International Livestock Exposition. There was a noticeable correlation between the placings and the body measurements, especially in the ram classes. It was evident that scale played a large part in the judges' selections. Animals which were average in most measure-

ments, but excellent in some, were apt to receive a high placing in the show ring. In general, finer and denser fleeces were found on the sheep rating highest in the show ring.

The diameter of fiber in the fleece of Angora goats was shown by studies at the Texas station to be unrelated to the type of lock. The weight of the fleece and the staple length showed little if any correlation with the belly covering, face covering, or fineness of fiber in ringlet and flat-lock type goats. Staple length was related somewhat to animal weight.

Digestibility studies with sheep at the Texas station showed that feeds high in feeding value were high in starch, or in starch and sugar combined, or in protein. The sugars and starches were highly digestible as contrasted with the pentosans, which varied according to the feed.

The energy requirements of growing sheep were found by the New Hampshire station to be greater than those of adult sheep. Since sheep mature earlier than larger domestic animals, their metabolism is high in proportion to the faster growth rate. The energy requirements were exceptionally high at birth and early in the suckling period, but thereafter dropped rapidly, and by the end of the fourth month reached a low level.

The use of wheat as a feed for livestock has received considerable attention during the past year. At the Nebraska station whole wheat was found to be practically as palatable as shelled corn for fattening lambs, but only about 87 per cent as efficient for producing gains. Ground wheat alone was less palatable than whole wheat, but produced gains better. Mixtures of 3 parts of ground wheat and 1 of ground corn or of equal quantities of shelled corn and whole wheat produced gains as rapid and economical as those produced by shelled corn alone. The Idaho station found wheat alone to be less valuable than either corn or barley in rate and economy of gains, and lambs were hard to keep on full feed when given wheat.

The heavier individuals among grade fine-wool ewes, the Montana station observed, raised a higher percentage of twin lambs. Culling the small ewes from the flock would not have eliminated any exceptional lamb producers and few that were equal to the average. Size was found to be a more accurate measure of a ewe's ability to raise heavy lamb crops than was the lamb-producing ability of her dam, and was the most accurate single criterion for the selection of fine-wool ewes.

Rotating pastures for sheep was found by the Nevada station to increase their carrying capacity from 40 to 50 per cent as compared with the capacity of pastures grazed continuously. This station also observed that the common belief that two lambs need the same amount of pasture as one mature animal is erroneous. Dry ewes confined to dry lot from early spring to late fall consumed about 12 pounds of lawn clippings per head daily, while a ewe and lamb ate more than 23 pounds and a ewe and twin lambs ate about 34.5 pounds. Approximately one-half of the first year's growth of lambs was made in the first 90 days, and at the age of 4 months lambs on pasture already had made their most economical gains.

Romney wethers on a fattening ration for six months at the California station produced 343 per cent more grease wool, and 320 per cent more scoured wool, and staple 172 per cent longer, and fiber 250 per cent stronger than a similar lot on a submaintenance ration.

Swine.—Nutritional anemia of young pigs has become a serious problem as swine production becomes more intensive and concentration of breeding animals increases, and has warranted rather extensive study of its cause. The results obtained at the Wisconsin station indicate a solution of the problem. Although the addition of iron salts to the feed of young pigs did not prevent anemia in confinement, the Illinois station found that brushing the sow's udder with a solution of iron and copper salts, when started soon after farrowing, prevented anemia during the entire suckling period. It insured consumption of enough of the salts during nursing to prevent the onset of anemia. At the New York (Cornell) station no anemia was apparent among pigs that received a daily dose of a solution of ferric sulphate or pigs which had dried ferrous sulphate mixed with their feed or those whose mothers' udders were painted daily with a concentrated solution of ferric phosphate. A check lot of pigs which received the same treatment but no iron compounds became anemic at from 3 to 4 weeks of age.

In studying the cause of anemia, the Indiana station found from analyses of pigs' livers that there was a prenatal storage of copper, iron, and manganese, which decreased as the pigs grew older, but the decrease in copper and manganese was more

marked in the anemic than in the normal pig. Ferrous iodide fed to sows from breeding time until their pigs were 4 weeks old did not prevent anemia. Sodium ferrate fed to a sow, beginning 10 days before farrowing, resulted in a normal hemoglobin content of the blood of her pigs. Pigs on bluegrass sod inside a hog house had a normal hemoglobin content in their blood.

Mineral supplements and their effect upon the animal organism continue to be of practical importance to producers of hogs, but some unfavorable results have followed the feeding of excessive amounts of toxic minerals. Deleterious effects of fluorine on swine were referred to on page 51. The Oklahoma station found that adding minerals increased the rate and economy of gains when feeds low in minerals were used as protein supplements to corn, but not when supplements rich in minerals were used. There were indications that minerals added to the ration should be limited to 1 per cent. Along the same line, the North Carolina station found that adding ground dolomitic or calcitic limestone, superphosphate, or a commercial mineral mixture to a ration of corn and fish meal already relatively high in minerals, not only decreased the rate of gain but also the economy of gain.

Comparing rations having wide and narrow nutritive ratios and changing the nutritive ratio while pigs were increasing from 40 to 200 pounds in weight, the Wisconsin station found that 60-pound pigs, fed a ration with a nutritive ratio of 1:5 until they weighed 100 pounds and a 1:6.2 ration to 200 pounds, gained as rapidly and as economically as pigs started on a nutritive ratio of 1:4.5 widened in three changes to 1:6.5 or 1:7.

That cottonseed meal, one of the cheapest sources of protein, can be used successfully in swine rations has been demonstrated by several of the stations. The Oklahoma station found that while cottonseed meal was not satisfactory as the sole protein supplement, combinations with tankage in proportions of 3:1, 1:1, or 1:3 were practically as good as tankage alone. A combination of cottonseed meal and fish meal fed by the North Carolina station as a supplement to corn produced rapid gains which required less feed and cost much less than when fish meal was the sole supplement. Ordinary cottonseed meal fed with tankage at the Ohio station, making up about 9 per cent of the ration, was not harmful, and was cheaper than tankage alone. Cottonseed meal, autoclaved for one hour at 14 pounds pressure, did not injure swine, even when it made up approximately 21 per cent of the ration. A cottonseed meal made by a special process produced more rapid growth than ordinary meals, and replaced tankage economically.

The swirl character, frequently observed in the hair of swine, was found by the Oklahoma station to be hereditary and transmitted by both the sire and dam.

Quality in meat.—A study of the factors influencing the quality and palatability of meat was selected as one of the subjects for cooperative investigation by the State experiment stations and the United States Department of Agriculture after the passage of the Purnell Act in 1925. As already explained (p. 9), many of the experiment stations are taking part in this cooperative study. A review of some results of this study follow:

Steers of all ages made larger and more economical gains than spayed heifers, in experiments at the Nebraska station, and the same was true of steer calves compared with open heifer calves, but yearling open heifers gained faster and more economically than yearling steers. Open heifers gained faster and more economically than spayed heifers. The dressing percentages differed little between 2-year-old and yearling steers and heifers, but both spayed and open heifers dressed considerably higher than steer calves. The steers and heifers of all ages, except steer calves, produced carcasses that were well marbled, of good color, and desirable size. Steers of all ages cut a smaller percentage of hind quarters than did heifers. In work at the Missouri and Illinois stations, heifer carcasses were found to carry more internal and external fat than did steer carcasses of the same age. Steers gained more rapidly and economically than heifers, but did not carry as much finish and were outdressed by the heifers. There was more waste to cuts from heifer carcasses than to cuts from steer carcasses. Discrimination against heifer carcasses was justified only from the standpoint of waste.

Cattle grazed on bluestem pasture did not produce dark-cutting carcasses, and while supplementary feed increased the finish, it had no effect on color in experiments made by the Kansas station. The blood of animals on grass was slightly higher in hemoglobin and calcium content than that of animals in the dry lot. The beef

ripened satisfactorily and was palatable, well flavored, and had a very desirable aroma. The discrimination against grass-fat cattle on the basis of color was thus shown to be unwarranted.

Other phases of the influence of feed were studied by the Illinois, Missouri, and Montana stations. A half feed for fattening animals was found by the Missouri station to produce more protein and water in carcasses than did a full feed. Alfalfa hay used by the Illinois station as the sole fattening feed produced coarse, tough, dry beef lacking in richness and somewhat undesirable in flavor and aroma. Barley-fed carcasses had a better finish and a more desirable color, in Montana station studies, than carcasses finished on corn.

In a study of the age problem in beef the Missouri and Iowa stations found that the carcasses of mature animals yielded heavier fore quarters and contained a higher percentage and a better dispersion of fat than those of younger animals. Immature carcasses contained higher percentages of water and protein than did those of older animals. Two-year-old and yearling steers, both as feeders and as finished animals, produced more desirable beef than did calves. Dressing percentages and cutting yields were higher in finished than in unfinished animals, but age did not influence the percentages of various cuts. While the meat of calves was lighter in color than that of older animals, the latter produced carcasses that were more satisfactorily marbled, and the beef ripened better than did the beef of calves.

There were no significant differences in dressing percentage, size of internal organs, color of lean, firmness of fat, toughness, or chemical composition of steers exercised daily and those not exercised, in a study by the Illinois station. No appreciable differences were found in the physical appearance or palatability of the meat. This station observed no marked difference in the color or hemoglobin content of the rib eye or the twelfth rib of steers killed by stunning and bleeding 10 minutes later and similar steers killed by the kosher method.

The percentage of beef blood carried by the animals did not influence greatly the birth weight, development before weaning, or rate and economy of gains in the feed lot of calves, in studies made at the Arkansas station. However, it did influence the selling price based on the carcass score.

Early findings made in the cooperative soft-pork studies and incorporated as a part of the cooperative meats investigation, referred to on page 9, in 1929 showed that soft pork was caused by the consumption of feeds high in fats melting at a relatively low temperature. When the ration contained sufficient carbohydrates and proteins to carry on the body processes of the animal, the animal fat was similar in character to the fat of the feed.

That soybeans and soybean forage produced soft pork has been shown by work at the Illinois, South Carolina, South Dakota, and Tennessee stations. The fact that soybean-oil meal did not cause soft pork indicated that the oil of the soybean was responsible. Rice polish and rice bran were found by the Arkansas station to cause soft pork, to harden which required about eight weeks' feeding on hardening feeds. Brewers' rice, on the other hand, produced firm pork and hardened soft pork faster than corn. At the Georgia station pigs that had been softened on peanuts could be hardened by feeding them for 10 weeks on either corn or sweetpotatoes.

Weight, condition, type, and fill were found to influence the dressing percentage of hogs at the Ohio station. Hogs with an average back-fat covering of 2 inches dressed approximately 1 per cent lower than hogs having an average back-fat covering of 2.4 inches. Bacon-type hogs outdressed lard-type hogs of approximately the same weight by 1 per cent. The Indiana station found that the fat of young swine was soft, but that it gradually hardened during growth and fattening. The percentage of fat in the fat tissues increased and the percentage of moisture and protein decreased as the thickness of the fat covering increased. These changes were accompanied by a lowering of the refractive index of the fat and an improvement in the quality of the meat.

Dairy cattle.—Economical milk production is the keynote of the dairy industry, and one of the most important factors affecting economy is the efficient utilization of low-priced feeds, especially roughages.

Kale fed at from 30 to 35 pounds per cow daily was found by the Oregon station to be practically equal to corn silage for milk and fat production, and a combination of kale and corn silage was economical. Kale fed within an hour before milking produced a characteristic and objectionable flavor and odor in both the milk and butter, but

when fed shortly after milking produced no objectionable effects.

Cows at the Iowa station produced 3.5 per cent more milk and 3.2 per cent more fat at 11.6 per cent greater return over feed cost when fed corn silage than while receiving recut corn fodder. Practically all silage was eaten, whereas a small part of the recut corn fodder was refused. A comparison of whole and recut corn fodder showed that the cost of recutting was justified.

Heifers grown on alfalfa hay at the Arkansas station had fairly normal lactations, while those receiving prairie hay could not produce milk and maintain body weight normally. Changing from prairie hay to alfalfa hay during the lactation period had a very beneficial effect. Growth on properly supplemented prairie hay was equal to that obtained on alfalfa hay.

The milk of different cows of the same breed varied considerably in the amount of yellow color present, in a study at the Illinois station. Cows kept under the same conditions varied in this respect with changes in feed. The color changed little during the lactation period. There were tendencies for cows to maintain the same percentage of color throughout their productive life, and for related individuals to show a similarity in color of milk.

No significant differences in the vitamin A content in the milk from Holstein, Jersey, Ayrshire, and Guernsey cows were found by the Nebraska station. Irradiated yeast fed to cows at the Wisconsin station increased the antirachitic potency of the milk. As much as 200 grams of yeast was fed without detrimental effect on milk production or butterfat content, and when the yeast was reduced from 50 to 10 grams daily there was still a noticeable effect on the antirachitic potency of the butterfat, although the effect on the milk was not clearly demonstrated. The station also showed that daily exposure to sunlight or artificial ultra-violet light did not improve the antirachitic value of the milk or butterfat. Irradiated egosterol fed at a level of 25 milligrams daily produced a slight improvement in the vitamin D content of butterfat in tests with cows at the Ohio station. At a level of 100 milligrams daily the vitamin D content was ten times greater than that before ergosterol feeding began.

Heavy feeding of cottonseed meal to dairy cows up to approximately 4 years of age, by the Michigan station, apparently had no harmful effects on health, reproduction, or milk production, and did not increase the susceptibility to udder infection. At the Oklahoma station heifers consuming an average of 6.2 pounds of cottonseed meal during gestation showed no unusual conditions at parturition, and the udders were soft and pliable during lactation. The milk production was about the same as that of heifers grown on regular rations. The North Carolina station concluded that satisfactory rations for dairy cows could be prepared from cottonseed meal, cottonseed hulls, and products of the corn plant. Necessary calcium was supplied by liberal quantities of gluten feed and stover, and the vitamin A by yellow corn. However, better results were obtained when cows were fed liberal quantities of legume hay or had access to pasture.

A ration of timothy hay, corn silage, and grain was found by the Michigan station to supply enough calcium and phosphorus for the production of at least 10,000 pounds of milk per year. During the height of production on this ration, the cows were often in negative calcium and phosphorus balance, but subsequent positive balances made up the losses. Cows receiving a low-calcium ration utilized calcium more efficiently than those on a ration high in this element, and there was a tendency for heavy-milking cows to utilize both calcium and phosphorus more efficiently than low-milking or dry cows.

Calcium assimilation due to green grass in the ration of cows, according to Wisconsin station experiments wherein commercial glucose replaced part of the grain and concentrated hydrochloric acid was added to the ration, could not be attributed to vitamin D or to the action of sugars or acids.

The flavor imparted to the milk by different feeds and weeds, and methods to control it, are of much practical importance. The influence of certain green feeds has already been noted.

Ground French weed (*Thlaspi arvense*) seed was mixed with the regular grain mixture fed to cows, and the green plant was also fed. After eating between 90 and 150 grams of French weed seed to 500 grams or more of the green plant, a cow at the Minnesota station produced in its milk a characteristic taint which was most pronounced when the interval between feeding and the milking was 3 hours, less after 5 hours, and absent after 12 hours. The odor was more pronounced in the cream and most pronounced in the butter, indicating that

the volatile products of the weed unite chiefly with the fats. The common methods of removing feed tastes from milk were only partly successful with French weed. French weed seed could be detected by the typical odor in mixed feeds containing as litttle as 0.5 per cent of the seed when enough water at 50° C. to moisten the entire mass was added.

In a study of the inheritance of butterfat production in Holstein-Friesian cattle, the Missouri station found indications that the sire's potential transmitting ability can most satisfactorily be designated as the average of the production of his daughters' minus 0.2 of the average of their dams' production. This station also observed that Jersey sires might cause some yearly changes in fat production without materially influencing body weight. It was also found that fat production was related to live weight and that the live weight of the daughters was somewhat related to that of the dams.

The sex ratio among the offspring of cattle in several Swedish breeds showed no tendency for departures from the normal sex ratio to be hereditary, in a study made at the Wisconsin station. The age of the parent had no influence on the sex of the calves, but as the dams' age advanced to 8 to 9 years there was a greatly increasing tendency toward the production of twins, which tendency was hereditary.

The value of fly repellents for dairy cattle has been studied at several stations. The North Carolina station did not find a marked difference in the number of flies on sprayed and unsprayed cows while on pasture, but in the barn the unsprayed cows were infested with about six times as many flies as the sprayed cows, and there was a slight increase in the milk production of sprayed cows. At the Kansas station two commercial fly sprays and one home-mixed fly spray repelled flies from barn-fed cows for from one-half to one hour, but made little difference in milk production. The New Jersey stations found it economical to spray cows as a protection against flies; when the cows were not sprayed, milk production fell off, and even the fat percentage of the milk of some cows decreased.

Poultry.—The use and value of minerals in poultry rations continue to claim the attention of investigators at many stations. The calcium and phosphorus requirements of growing chicks are of special interest and important contributions have been made to the knowledge on the availability of these elements for bone formation.

Raw bone meal was found by the Kentucky station to equal or excel a combination of raw bone meal and limestone as a mineral supplement for growing chicks. The Ohio station found no difference in the availability of calcium in its carbonate, sulphate, lactate, and phosphate salts or in limestone, steamed bone meal, rock phosphate, phosphatic limestone, or oyster shell for bone formation in the growing chick when the supplements were fed at the same calcium intake level, on a minimum requirement basis. The New Jersey stations found that chicks could utilize the calcium better when it was fed in the form of oyster shell or limestone than when it was fed as tricalcium phosphate, the calcium of which in turn was better utilized than that of calcium carbonate.

The New York (Cornell) station found that with an optimum amount of antirachitic factor in the ration for normal growth of chicks the calcium-phosphorus ratio should vary between 1 : 1 and 2.2 : 1. When this ratio was increased to 3.3 : 1 nutritional disturbances followed. The Wisconsin station found the optimum calcium-phosphorus ratio to lie between 1 : 0.5 and 1 : 0.25 when vitamin D was present and the ration contained from 0.61 to 1.13 per cent of calcium and 0.3 per cent of phosphorus. When the basal ration contained from 2.49 to 2.71 per cent of calcium and from 0.66 to 0.83 per cent of phosphorus, with a minimum amount of vitamin D, a calcium-phosphorus ratio of 1 : 0.26 to 1 : 0.3 produced the best deposition of calcium in the bones and growth. The Wisconsin station fed glucose and hydrochloric acid in varying amounts to increase the utilization of the calcium and phosphorus of the ration, but neither increased the bone-ash content of the chicks.

Heavy egg production in poultry, requiring the output of large amounts of calcium in the eggshells, has been shown to depend on an ample supply of vitamin D for the laying hen in addition to adequate quantities of calcium and phosphorus.

In rations for both pullets and yearling hens the absence of a vitamin D supplement was shown by the Kentucky station to materially reduce egg production, and to bring about a progressive decrease in hatchability of eggs. Direct sunlight proved to be more effective than either irradiation or cod-liver oil for increasing egg production and hatchability.

Winter sunlight in southern Wisconsin proved of decided value as a vitamin D carrier in studies at the Wisconsin station, although the production and hatchability of eggs laid by birds exposed to such sunlight were not equal to those of eggs laid by birds irradiated with a quartz-mercury lamp.

Growth was subnormal and there were indications of rickets among lots of chicks fed irradiated ergosterol at the Nebraska station. Birds at the Illinois station fed a ration treated to destroy the vitamin E content, when mated to normal males produced eggs reasonably fertile but failing to hatch. Few of the eggs laid by these birds developed beyond the ninth day of incubation. The addition of a small quantity of wheat-germ oil to the ration brought about a progressive increase in the hatchability of the eggs.

The calcium content of the blood of hens has been found to fluctuate widely, being very high before the deposition of the shell on the egg. With inadequate blood calcium, less than the normal amount of eggshell is laid down and the number of eggs laid is reduced. A rather extensive study of blood calcium of hens was made by the Kentucky station. Birds receiving a ration not supplemented with calcium carbonate became nervous and inactive. During a 6-week period the blood-calcium content decreased about 27 per cent, the average contents of the eggs laid by these hens 11 per cent, the average weight of dry shell 21 per cent, and average egg production 78 per cent. In nonlaying hens the arterial blood going to and the venous blood coming from the intestines contained about the same quantity of calcium. The calcium content of the blood was higher in the laying hen than in the nonlaying hen.

A study of the growth of White Leghorn chickens at the Illinois station showed that the birds increased in size in such a manner that their conformation, exclusive of feathering, did not change materially. Pullets were consistently broader at the hips and larger in midcircumference, but had shorter legs than cockerels. The weights of most of the organs and parts of the carcass increased progressively with the body weight. The pullets fattened more rapidly and continuously than the cockerels, which showed no further tendency to fatten after a weight of 2 pounds was attained.

Hatching percentages, the Minnesota station observed, were higher and abnormalities less common in eggs laid before 9 a. m. than in eggs laid later in the day. Evidently those eggs laid early in the morning include a considerable percentage held over in the oviduct long enough for development to advance beyond the stage most likely to be unfavorably affected by cold.

That temperature profoundly influences the rate of growth of chick embryos was shown in experiments at the Missouri station. The influence was at its maximum during the earliest stages, decreasing progressively and practically stopping when the embryo was about 16 days old or when it reached a dry weight of about 2 grams. The temperature-regulating mechanism of the embryos began to function at about 16 days. The temperature limits for growth to a weighable size were from 34° to 42.2° C. at an average relative humidity of about 60 per cent. The growth rate was fairly constant through several stages, but there were indications that an increase in temperature shortened the stages and shifted the limits. As a rule, the limits coincided with the changes in the type of chemical compound in the egg used by the chick for energy.

Extremely high humidity in the incubator was shown by the New York (Cornell) station to hasten growth of the chick embryo, while low humidity retarded growth, yet both extremes decidedly disturbed the cycles of growth. At certain stages in the development of the embryo, the calcium metabolism was much better at high than at low humidity. At high humidity the mortality rate was increased at the nineteenth day of incubation. Both extremes of humidity produced slight changes in the yolk sac, which probably affected the metabolism of the embryo, leading to low vitality and susceptibility to environment.

The highly competitive nature of the poultry industry makes it necessary to consider all factors influencing the productiveness of laying hens. Seasonal production is related to the date on which pullets lay their first eggs and other characteristics of the laying cycle and physiological response of the birds.

Pullets that laid their first eggs early in the laying year were, as a rule, of earlier sexual maturity than those laying their first eggs later in the year, in experiments at the Iowa station. Birds starting to lay in September had the highest winter production, those beginning in December had the highest spring production, while

birds that laid their first eggs in March had the poorest annual production.

No indications that hatching date affected the duration of complete molt were found by the Massachusetts station. The age of the fowl when the first egg was laid was not significantly correlated with the length of molt. The length of winter pause, total days broody in the pullet year, and gain in body weight were independent of length of molt, and vigor did not affect the duration of molt. In general the poorest layers had the shortest molt period, indicating that molting and feather growth go on rapidly in heavy layers.

A study of the relation of temperature to egg production, carried on at the Oklahoma Panhandle station, showed that temperature changes during February and October had the most noticeable effect on egg production. On the whole, however, other climatic factors had more influence on production than temperature alone.

A study of the influence of disturbances of fowls upon the rhythm of egg production at the Kansas station indicated that the eggs in the oviduct in the hen are more subject to the retarding effect of the disturbance than the egg not yet released from the ovary. Handling alone was found to have practically no influence on the interval between the eggs, while catching the birds and moving them to other quarters increased the interval in the laying cycle between the eggs 7.3 hours.

Information on the influence of feeding and management on the storage quality of eggs is of much practical value.

There is a popular notion that eggs produced by hens fed cottonseed meal do not store well. Excellent eggs for storage purposes were produced at the Oklahoma station when the mash fed the hens contained 7 per cent of cottonseed meal, but mash containing one-third cottonseed meal produced eggs that developed olive-green yolks during storage. Green or olive yolks occurred frequently among storage eggs at the Mississippi station only when large quantities of cottonseed meal were used in the ration. Olive yolks caused by cottonseed meal were found by the Oklahoma station to be wholesome and free from bacteria, to have no foreign flavor or odor, and to change to yellow when the egg was cooked or the yolk whipped. The hydrogen-ion concentration of the yolk increased and that of the white decreased when cottonseed meal was fed in quantities sufficient to discolor the yolk. Olive yolks increased in size and weight during storage, apparently because of the absorption of water, but there was no change from normal in either the ammonia or protein nitrogen of such eggs.

Chicks hatched from eggs produced by hens fed pimento peppers, at the Georgia station, began to show pigment in the shanks when from 5 to 6 days old. At hatching time there was no visible difference in the color of the shanks of these chicks and those hatched from ordinary eggs. Usually cockerels from eggs produced by hens fed pimento had more pigment in the shanks than pullets so fed. Feeding pimento peppers to birds imparted a rich yellow color to the shanks, skin, and fat, the coloration depending upon the quantity of pimento fed, but such feeding did not add any characteristic flavor to the meat.

Crossing Brahma and White Leghorn fowls in a study of the inheritance of body weight of poultry, the Rhode Island station observed that the crossbred birds were intermediate between the two parents in weight. The second-generation birds from the cross were highly variable, and individuals from this generation produced widely different offspring, indicating that the variability of the weight in this generation had a genetic basis. The weight differences in the parent breeds seemed mainly due to two pairs of genetic factors which were equal but cumulative in their effects. The growth rate of the hybrids followed that of the heavier parent up to about seven months.

In a study of crossbreeding Single Comb White Leghorn, Single Comb Rhode Island Red, Jersey Black Giant, and Barred Plymouth Rock fowls, the Kansas station found that the hybrids were superior to purebreds in most comparisons based on production and vigor, although showing a greater tendency toward broodiness. In a test in which two different strains of Single Comb White Leghorns were used, the stimulation from crossing was not so apparent.

Studies of the factors affecting egg weight in the domestic fowl, in which birds of different rates of production were used, were made by the Pennsylvania station. Body weight, the single factor appearing to be of primary importance, accounted for from 19 to 32 per cent of the variability in egg weight in the different groups studied.

In a study of the inheritance of shank feathering, the Iowa station found that all crosses of Black Langshans with White Plymouth Rocks and Buff Orpingtons were shank feathered, but to a lesser degree than the Langshan parent. It appeared that there were two dominant Mendelian factors, the color factor and sex, inherited independently of each other and either one capable of producing shank feathering, although but one factor appeared to be linked with a factor for skin color. The tendency to crooked or straight keel bones, salmon breast in White Leghorns, certain breed characteristics, and rate of maturity were found by the Kansas station to be inherited.

In studies of the inheritance of certain morphological characteristics in poultry, the Connecticut (Storrs) station has given attention to the rumpless character, the creeper fowl, and the frizzle fowl. The creeper trait, characterized by extremely short longbones, was due to a single Mendelian factor dominant to the normal. In the homozygous condition it was lethal; consequently all creeper fowls were heterozygous and when mated inter se produced approximately two creepers to one normal. In matings of creepers with normals, about equal numbers of birds showing the creeper character and normal chicks were produced. In case of frizzle fowls, it appeared that a single pair of factors accounted for the differences between birds showing the frizzle character of the feathers and the normal type of feathering. There was no lethal action of the frizzle gene, but embryonic mortality was high and hatchability low if females of the exhibition type or homozygous females were used, even when mated with normal birds.

A knowledge of the time required for the fertilization of eggs, the duration of such fertility, and the influence of successive matings by different males is important in poultry breeding.

Study by the Oklahoma station on the fertilizing powers of males showed much variation in the number of sperm in semen samples and in their motility, the maximum appearing during the second year. Matings in rapid succession lowered the number of sperm found. Two days or more after mating were required before fertile eggs were laid, and the duration of the fertility from a single mating of a female was not more than 14 days.

The freshness of the sperm was found in Kansas station studies to be an important factor in fertilization. When the male bird in a pen was changed for another practically all of the offspring were sired by the recently introduced male within a very few days. Sperm introduced later lost their advantage after remaining in the oviduct for more than one day. Laboratory studies showed this to be due to the fact that the sperm lost their power of motility during the first day in the oviduct. Apparently the rate of laying did not influence the duration of fertility resulting from a successful mating.

HENRY W. MARSTON.
GEORGE HAINES.

DAIRYING

Consumers demand dairy products of good quality handled in a sanitary way. The producer must be able to supply such products at a profit to himself. The interests and problems of both producer and consumer are kept in mind in the work of the experiment stations. A few examples of recent station work bearing especially on quality of dairy products are as follows:

The flavor of cream kept in air-tight containers was found by the Indiana station to be more desirable than that of cream exposed to air. The growth of bacteria, yeasts, and molds was less in the cream held in the air-tight container. A bitter, woody, surface taint noted in whipped cream was traced by the Illinois station to odors given off by exposed wooden surfaces, particularly yellow pine and ash, in the refrigerator. Some woods caused this off flavor when wet but not when dry. Covering the whipped cream with an air-tight cover reduced the danger of taint to a minimum.

A number of stations have found a definite relation between the feed consumed by a cow and the body and texture of the butter made from her milk. The California station found a ration restricted to dry alfalfa to be at least one cause of sticky, crumbly butter during the winter months. In experiments reported by the Mississippi station, rations containing cottonseed meal produced harder butter than those containing linseed meal. In experiments reported by the Arkansas station, adding rice polish to the ration increased the hardness of the butter. The change in the character of the butter was directly proportional to the quantity of rice polish fed.

A method of handling surplus sweet cream proposed by the Massachusetts station is to freeze and store the cream for use later in ice-cream mixes. Adding 10 per cent of sugar to the sweet cream gave the product a more uniform body when thawed, and the ice cream made with this product was superior in flavor, whipped faster, and contained smaller fat globules and clumps than ice cream made with plain frozen cream. It was found that cream that is stored for periods of less than six months should be kept at a temperature below 0° F.

The above and other examples of recent station work in dairying are reviewed at somewhat greater length in the following pages.

Cooling milk.—To be of high quality and to keep well, milk must be cooled promptly after it is drawn. The Vermont station found that deterioration in the quality of milk was roughly proportional to the length of time that had elapsed before the milk was cooled.

Methods of cooling milk have been studied at a number of stations. The New Hampshire station found that refrigerated tanks, in which cans are immersed, should contain from 3 to 5 gallons of water to each gallon of milk.

The bacterial growth in milk during a 12-hour to 14-hour storage period was found by the Indiana station to be slight when the water in a cooling tank was maintained at from 35° to 45° F., but was nine times greater when the water was maintained at 55°. Only when the cooler was carefully washed and sterilized did precooling milk over surface coolers give lower bacterial counts than not precooling.

In experiments in cooling milk the Vermont station found that milk in 40-quart cans immersed in water at 32° F. and not stirred, required 1¼ hours to cool from 90° to 50°, cooling most rapidly during the first 15 minutes. When warm milk and ice were simultaneously placed in water at 70°, 3½ hours were required to cool the milk to 50°. Milk cooled with air at from 3° to 12° required from 5½ to 6 hours to get down to 50° and snow-bank cooling likewise was a slow process.

Wet storage type coolers called for an average expenditure of 1 kilowatt hour of electricity to cool 100 pounds of milk, in tests made by the Connecticut (Storrs), New Hampshire, and Vermont stations.

In cooperative tests of different types of strainer materials for removing sediment from milk, the Michigan station found that the higher the temperature of the milk the more rapidly it passed through the strainer. The length of time required to pass through the strainer also depended upon the thickness and nature of the material. Of the various cloths used, flannel most effectively removed sediment from milk, although not equal to cotton pads. The latter were very efficient and rapid when not more than 10 to 15 gallons were strained through the same pad.

Carbonation of dairy products.—Investigating the use of carbon dioxide in the preparation of dairy products, the Illinois station found that carbonation tended to prevent the growth of some species of bacteria and to prolong the keeping period of the product, but had no effect on other species of bacteria. Carbonated raw milk held at 70° F. at a pressure of 60 pounds did not spoil until the ninth day, while uncarbonated raw milk spoiled in two days. Carbonating freshly pasteurized milk and holding it at about 40° and 180 pounds pressure completely prevented growth of bacteria. Carbonation of a product which already had a high bacterial count did not appreciably affect its keeping quality. Carbonation did not reduce the number of bacteria in ice cream to a significant extent. Butter made from cream carbonated at churning had, when fresh, a sour taste which disappeared in a few days. Storing butter in a carbon dioxide atmosphere prevented certain undesirable flavors and the growth of surface molds. Growth of mold on cheese was prevented by similar storage.

Off flavor in cream.—The Indiana station found less growth of bacteria, yeasts, and molds in cream held in air-tight containers. Cream that had been kept in an air-tight container, and the butter made from it, had a more desirable flavor than that exposed to the air.

Quality in butter.—The relation of feeds to the body and texture of butter has been studied by a number of stations.

Butter produced by the Mississippi station on a ration containing cottonseed meal was harder than that produced on a linseed-meal ration. Corn and sorghum silage rations produced about equally good butter, that from corn-silage rations having a slightly higher melting point. The quality of butter differed little when the roughage consisted of either alfalfa, fine-stemmed soybean, or lespedeza hay. Butter from Jersey cream churned quicker than that from Ayrshire cream, and the buttermilk contained less fat. The butter granules of Ayrshire cream were often soft and hard

to work. The Arkansas station found a definite increase in the liquid portion and a decrease in the solid portion of fat separated from butter produced from the milk of cows receiving varying quantities of rice polish, the change in the fat being directly proportional to the quantity of rice polish fed.

Fat losses in buttermilk were found by the Minnesota station to be lower when cream was held overnight at the churning temperature or held for from two to four hours at 32°+ F. before churning, than when the cream was churned immediately after being cooled. Overloading the churn resulted in a slight increase in the fat content of the buttermilk.

General tendencies toward a decrease in bacterial counts in salted butters and toward increased counts in unsalted butter during storage were found by the Minnesota station. The ratio of increase was higher in the unsalted than in the salted butters, while the opposite was true for the ratio of decrease. The salt content of butter had a decided effect upon quantitative changes in the microflora of butter during storage, but not in proportion to the quantity of salt present.

Ingredients in ice-cream mixes.—The use of condensed and dried milks in the manufacture of ice cream is becoming more common because of their convenience and keeping qualities. The New York (Cornell) station found that all four types of dry skim milk—spray, flake, vacuum roll, and atmospheric roll—made ice cream of satisfactory quality. However, the atmospheric-roll powder was relatively insoluble and imparted a cooked or custardlike flavor which was distinctly noticeable. This power slightly impaired the whipping properties of an ice-cream mix, but somewhat improved the texture of the ice cream. Similar results were obtained with this type of powder by the Pennsylvania station, where its use increased the viscosity and acidity of the mix.

Using skim-milk powder in place of condensed skim milk as a source of serum solids, the Michigan station improved the whipping properties of an ice-cream mix without effect on the body, texture, or melting resistance of the ice cream. Using dry skim milk in ice-cream mixes in which cream and milk constituted the source of butterfat the Pennsylvania station produced ice creams scoring as high as controls containing condensed skim milk. Ice cream made at the New York State station with dry skim milk that had been stored in sealed containers for several months had good keeping qualities, but it was not possible to make good ice cream with dry skim milk kept unsealed for 60 days.

Storing frozen sweet cream for use later in ice-cream mixes was found by the Massachusetts station to be a satisfactory method of handling surplus cream. Such cream should be stored for less than six months at below 0° F. Plain frozen cream reduced the whipping properties of the mix, lowered the maximum overrun, increased the viscosity, and caused slightly larger and more irregularly sized fat globules and clumps than were present in sweet-cream mixes. However, cream frozen with 10 per cent of sugar melted more rapidly and had a lower viscosity and a more uniform body than plain frozen cream. Mixes made with sweetened frozen cream were superior in flavor, whipped faster, and contained smaller fat globules and clumps than mixes made with plain frozen cream.

All forms of egg yolk decreased the freezing time of ice-cream mixes in experiments at the Massachusetts station. Fresh egg yolk was most effective in this respect, and dehydrated yolk was superior to frozen yolk. Egg yolk decreased the freezing time of a butter mix more than it did that of a cream or cream and butter mix, and also decreased the freezing time of a mix low in butterfat more than that of a mix high in butterfat. Adding egg yolk improved the whipping property of a mix high in serum solids more than that of a mix low in serum solids. Egg albumin apparently had no effect on the time required for freezing.

Flavors for ice cream.—A good grade of cocoa was found by the Kansas and Iowa stations to impart a more desirable flavor to chocolate ice cream than either chocolate liquor or prepared chocolate. The Kansas station found that the addition of the prepared sirups to a standard mix increased the freezing and whipping time and seriously impaired the standing-up properties of the ice cream. These sirups produced extremely variable flavors, which were not so desirable as the flavor produced by high-grade cocoa. The Iowa station found that the addition of such ingredients as cinnamon and caramel modified rather than improved the flavor of chocolate ice cream, and that the improvement in flavor through the use of vanilla extract was not evident enough to justify the expense. Homo-

genizing chocolate ice-cream mixes had no effect on the flavor.

Cheese making.—The use of skim-milk powder in standardizing milk, the Idaho station observed, had no measurable effect upon the flavor, body, and texture, or on the total score of Cheddar cheese made from the milk. As the quantity of skim-milk powder used increased, the loss of fat in the whey decreased. The increased yield of cheese obtained by the use of standardized milk was due to the efficiency of the solids not fat of the skim-milk powder, the higher moisture content of the cheese, and the decreased fat loss in the whey. High-test milk standardized with skim-milk powder produced cheese of the same quality and composition as low-test milk and at a lower cost.

Standardizing the milk used in making American cheese to a casein-fat ratio of 0.7 : 1 with skim milk, was found by the Wisconsin station to decrease the yield of cheese per 100 pounds of milk and the fat content of the cheese, to increase the moisture, to lower the quality slightly, and to raise the value of the product obtained from a unit of milk. The effect of standardizing was most noticeable when the milk contained more than 3.5 per cent of fat and disappeared when the fat content was approximately 3.3 per cent.

HENRY W. MARSTON.

ANIMAL DISEASES

A steady advance was made during the year in research on the diseases, parasites, intoxications, etc., of animals, that each year exact a tribute of millions of dollars from the American farmer. The progress of such work as eradicating infectious abortion from breeding herds and pullorum disease from flocks of poultry through tests largely perfected at the experiment stations, and protecting poultry from fowl pox by vaccination, emphasizes the practical value of knowledge gained from research. Particularly noteworthy is research work of the stations on the causative organism of laryngotracheitis and the recognition and description of two new forms of coccidia of the fowl. Mention should be made of the advancement of knowledge on poisonous plants which cause losses of stock on the range, on mastitis of the dairy cow and its prevention, on avian coccidiosis, and on several new diseases of livestock.

Infectious abortion was reported by the Connecticut (Storrs) station to have been eradicated from 35 dairy herds. The economic loss suffered from this disease was demonstrated by the finding of the Michigan station that abortions are two and one-half times and sterility eight times as frequent in reacting animals as in nonreactors.

The loss caused by goiter in lambs was prevented at the Iowa station by allowing the ewes during the last eight weeks of gestation free choice of a mixture of 1 ounce of potassium iodide per 100 pounds of flake salt.

Working with poisonous range plants the Texas station found that a form of swell head which at times causes heavy losses of sheep and goats was caused by a plant of the genus Agave. That station also found the broad-leaved milkweed to poison sheep and goats. Fitweed, a plant which grows on the higher range in Nevada, was determined by the station to be dangerously poisonous, in small quantities, to sheep and cattle. A small quantity of immature green bitterweed was found by the Texas station to cause the death of a sheep.

Among the diseases of poultry, pullorum disease continued to receive particular attention. In endeavors to simplify the means of detecting this disease, the agglutination test was found more reliable than the intradermal or wattle test. The application of a 5 per cent solution of sodium acid sulphate at the rate of 1 gallon per square foot of soil, the Tennessee station determined, effectively disinfected the soil of a poultry yard and protected against pullorum disease from this source.

The use of the cutaneous method of vaccination against fowl pox continued to spread. The Western Washington station reported results that appeared to justify the use of vaccine on pullets 3 and 4 months of age. (See also p. 69.) The use of a pigeon-pox vaccine on chickens did not reduce egg production at the Oregon station whereas the fowl-pox vaccine caused a decided drop. The pigeon-pox vaccine was found by the West Virginia station to be a satisfactory immunizing agent for fowl pox, and was followed neither by ill effects nor by lower egg production. The Hawaii station demonstrated that fowl pox is transmitted to baby chicks by mosquitoes and may be prevented by screening the runs and houses.

The infectious nature of the comparitively new disease of poultry which affects the larynx and trachea and is known as laryngotracheitis was deter-

mined by several stations. In comparative studies the Massachusetts station found immunological differences between acute and chronic cases. Two new species of coccidia affecting the fowl were differentiated by the Oregon station.

Accounts of other results of station work on animal diseases are included in the following review.

Infectious abortion.—The activity in research and the application of present knowledge in the combat with infectious abortion of cattle and other livestock continued. This work has already brought about the establishment in a number of States of many abortion-free breeding herds which are serving as nuclei in building up clean herds.

The abortion disease, the Connecticut (Storrs) station reported, has been completely eradicated from 35 herds and practically eliminated from 16 others, with 80 herds under observation. As an example of the practicability of maintaining a herd free from abortion infection, there is cited a herd of 178 females kept free from abortion since 1925, although no precautions were taken other than in the introduction of animals, and the barns were always open to visitors. The agglutination testing of animals in this herd during the four and one-half years passed seemed to show clearly that blood-positive reactions do not occur in a clean herd although some nonspecific reactions, usually slight, may occur in the lower dilutions.

The importance of eradicating this disease was emphasized in a study made by the Michigan station of a purebred dairy herd comprising from 60 to 100 animals of breeding age, in which infectious abortion had existed for 20 years. It was found that positive-reacting animals had two and one-half times more abortions than negative animals, and that sterility was four times more frequent in suspicious animals and eight times more frequent in positive animals than in those with a negative history. Sixty-two per cent of the positive animals and 11 per cent of suspicious animals had *Brucella abortus* in the udders. The abortion organism was completely eradicated by the Kansas station from a barn thoroughly saturated with abortion infection by two thorough cleanups followed by whitewashing and three months of summer sunning during which the premises were kept free of cattle.

Infectious abortion was successfully eliminated from a small herd by the South Dakota station through the application of the agglutination test, sanitation, and replacement of animals removed by new animals that had reacted negatively to the test. In work with seven experimental herds, the New Hampshire station found that infectious abortion can be handled by the agglutination test combined with a practical plan of sanitation and isolation of each of the groups of negative, positive, and suspicious reactors.

In eradication experiments the Kansas station found that calves up to 3 weeks of age, born in an infected herd and fed abortion-infected milk, will react positively to the agglutination test, but when removed from such an environment to clean surroundings and fed abortion-free milk will in all cases become completely negative in periods ranging from three to eight weeks and will continue to react negatively.

The survival of the causative organism of infectious abortion on grass in pasture was found by the Kentucky station to be of short duration, not longer than 24 hours in May at a temperature varying from 60° to 81° F. and in February with a temperature of from 10° to 70° for as long as 6 to nearly 10 days.

That the causative organism of infectious abortion produces definite changes in the bovine udder which may be quite extensive and may lower the efficiency of the organ considerably was indicated by studies at the Michigan station. The udders of 69 per cent of 65 cows reacting to the agglutination test for abortion disease contained the causative organism associated with pathological changes. A study by the Ohio station of the relationship of the cow's udder to resistance to *Br. abortus* infection indicated that the udder, gravid uterus, and lymph glands are the only tissues in which the organism will thrive.

In the vaccination of cattle against infectious abortion, the Michigan station established the fact that a nonvirulent culture is effective in preventing the disease and is perfectly harmless.

In vaccination experiments with live cultures of infectious abortion at the Texas station, 12.2 per cent of the cows vaccinated and calving during the year aborted, or about one-half as many as during the decade preceding vaccination with live cultures.

Infectious abortion of swine was found by the Michigan station to be caused apparently by a single species of Brucella, *Br. suis*, and its course can be followed accurately by the rapid agglutination test. This infection in swine appears to be a self-eliminating disease, the majority of animals recovering within five months from the time agglutinins first appear in their blood. The infection appears to be confined chiefly to the lymphatic tissues, its capacity to invade the gravid uterus being limited.

Immunization against infectious abortion in mares should, according to the Kentucky station, be done before late fall or winter and the immunity established early in the season.

Experiments in the control of infectious bovine abortion led the New Jersey stations to conclude that, in general, animals positive to *Br. abortus* can not be cured by the use of organic iodine. Vitamin carriers, or similar supplements, included in the ration by the Wisconsin station, did not lessen the ravages of a disease like infectious abortion.

Agglutination tests of bulls, made during a study of sterility at the Oregon station, indicate that there is no relation between infection with *Br. abortus* and the occurrence of adhesions of the testes and scrotum.

Mastitis.—This udder disease of the cow, which often causes the loss of the affected milk wells, received increased attention. Treatment by ultra-violet ray radiation applied directly to the quarter affected in 14 cows was found by the Idaho station to be an efficient means of eliminating clinical symptoms of the chronic form of the disease, such as flaky milk, swelling, and fever. It appeared, however, that there was no change in the bacterial flora of the quarter following treatment. In a persistent outbreak of mastitis in a dairy herd this station found *Pseudomonas aeruginosa* to be the predominant cause. Contamination of the water supply with this organism was responsible for recurrent cases of mastitis in the outbreak.

A living autogenous streptococcus vaccine for mastitis of cattle gave very satisfactory results at the Michigan station. The use of autogenous herd bacterins by the Connecticut (Storrs) station to prevent the spread of infectious mastitis was practiced in three commercial dairy herds during two years, without severe cases of mastitis occurring in two herds during the last 18 months and only occasionally in the third.

Infection occurred, in experiments at the Wisconsin station, when the septic sore throat organism (*Streptococcus epidemicus*) was rubbed lightly over the teat of a healthy cow, indicating that in this way cows may readily become infected.

Anaplasmosis.—In continuation of the study of anaplasmosis, a disease of cattle somewhat similar to cattle-tick fever, the California station found that animals which had apparently recovered from anaplasmosis remained carriers of the disease for at least two years.

Iron, manganese, and copper were found by the Kansas station to build up the hemoglobin content of the blood but not to increase the animal's resistance to anaplasmosis. The blood of carriers or recovered animals retained the ability to transmit the disease as readily as blood taken from acute cases of anaplasmosis. Carrier or recovered animals were found to be resistant to infection. Calves from infected and healthy animals did not sicken following their inoculation with blood taken from an acute case of anaplasmosis. Calves inoculated with infected blood seemed to acquire a resistance to the disease. Many infected animals appeared to recover completely after six months, except for the continuation of cell inclusions. The studies seemed to indicate clearly that care, water, feed, and protection from flies and sun are important factors in minimizing losses from anaplasmosis.

In the course of a study made by the Oklahoma station of the transmission of anaplasmosis by flies, an 8-year-old healthy cow, that had been exposed to a total of 41 bites by three species of tabanid flies, developed a typical case of anaplasmosis at the end of 112 days and died from the disease 117 days after the exposure.

Other diseases of cattle.—In reporting upon further work with the hemorrhagic disease in cattle, the Nevada station called attention to the fact that the stage of the liver fluke in which it first enters the liver and before it has penetrated to the bile ducts may be an intermediary agent, spreading the hemorrhagic disease among animals that swallow the causative organism in contaminated food and water. This station reported the first death of a hog due to *Bacillus hemolyticus*, the cause of hemorrhagic disease of cattle.

The bone-chewing habit and losses from loin disease were successfully checked by the Texas station by feeding bone meal.

That a deficiency of sugar in the blood is not analogous to milk fever, and that the bovine tolerates a much lower blood-sugar level than is reported for other species, have been demonstrated by the Minnesota station.

Studying bovine coccidiosis, the Virginia station found *Eimeria zurnii* to be the most common species, although *E. smithi* and *E. cylindrica* n. sp. usually were present in infected animals. Cross-infection experiments with swine and goats led to the conclusion that these species of coccidia are largely restricted to bovines. In this study it was observed that the winter temperatures encountered in Iowa destroyed oocysts or reproductive bodies of these three species of coccidia. Drying in the direct rays of the sun for 24 hours killed oocysts of bovine origin, but drying in the shade was less effective. It was found that an animal suffering from an acute attack of the disease may continue indefinitely as a carrier.

Disease of the horse.—A peculiar disease of equines involving the central nervous system, which appeared in parts of the San Joaquin Valley, Calif., early in July, 1930, resulted in a loss during the year of about one-half of the 6,000 horses and mules developing recognizable symptoms. Investigations by the California station cooperating with the Hooper Foundation have shown that clinically as well as anatomically this disease, when produced experimentally, is an acute virus infection identical with that appearing spontaneously, the infective agent, a filtrable virus, having been demonstrated in the central nervous system. In the summer of 1931 the disease was reported to be distributed widely in California and parts of Oregon.

The relative efficiency of different remedies in expelling the horse botfly larvae from horses was found by the Illinois station to be 99.3 per cent for liquid carbon disulphide, 91 per cent for mass powder carbon disulphide, and 92 per cent for chlorinated carbon tetrachloride.

Stomach worms of sheep.—In continuation of control work with the stomach worm, a limiting factor in profitable sheep production, the Texas station obtained very encouraging results with sheep and goats from the use of a 1.75 per cent solution of copper sulphate plus 1 per cent of a commercial preparation containing 40 per cent of nicotine sulphate as a drench.

A 4-ounce dose of suspension of colloidal iodine containing 1 per cent of iodine and a sulphate in solution, administered by the drench method was found by the Michigan station to enter readily the fourth stomach and to be effective in killing the stomach worms in 97 of 98 lambs treated. The use of sulphates may be avoided if the strength of the dose be increased proportionately or at the rate of a 6-ounce dose of a 0.66 per cent solution.

In control work with stomach worms of sheep at the Kansas station, the entire station flock was drenched with a 1 per cent solution of copper sulphate each 28 days after April 1 through the grazing season, during which time the sheep grazed on bluegrass, bluestem, orchard grass, rape, rye, Sudan grass, and sweetclover at different periods. Post-mortem examinations made of the fourth stomachs of some 50 of the sheep slaughtered during four years revealed practically no stomach worm infestation.

Drenching sheep with 6 ounces of a suspensoid (containing 0.66 per cent I_2) completely destroyed all stomach worms in all lambs in a flock of 16 animals in experiments at the Michigan station.

The administration of tetrachlorethylene at the Oregon station stopped death losses due to *Ostertagia circumcinta*, the common stomach worm of sheep on the Pacific coast.

Other diseases of sheep.—Studies of coccidial dysentery in feeder lambs during several years have led the Colorado station to a system of management which it is believed will be effective in handling an outbreak. Urinary calculi were detected in the kidneys, ureters, bladder, and urethra of sheep by the Indiana station, but in only a few cases were they found in all of these organs in the same sheep.

Studies of acidosis at the Kentucky station indicated that acidosis in pregnant ewes is fundamentally a problem of nutrition. The blood of ewes suffering from acidosis showed a calcium content below that of ewes fed a well-balanced ration and free from acidosis. Individual animals appeared to differ decidedly in their ability to maintain the calcium content of the blood when kept under the same conditions and fed the same kind of feed.

Sore mouth of kids and lambs was shown in experiments by the Texas station to be infectious and probably communicated more readily and in more severe form from kid to kid than from kid to lamb. In a study of an outbreak of pink eye in sheep, this station found the disease to be infectious by direct transmission and by contact. The station also observed

that the sheep-scab mite can not live longer than 25 days off the host, nearly all the mites perishing within 10 to 15 days.

In combating the sheep botfly, the Idaho station found that 3 cubic centimeters of a solution of equal parts of carbon disulphide and light mineral oil, when introduced into each nostril of the sheep, is of decided value in killing the larvae in the sinuses.

Poisoning and poisonous plants.—A form of swell head of sheep and goats occurring in the western part of Texas, and sometimes the cause of heavy losses, was found by the Texas station to be due to the range plant *Agave lecheguilla*. Other range plants, however, appear to have similar toxic properties.

The broad-leaved milkweed (*Asclepias latifolia*) was found by this station to be poisonous for sheep and goats, the toxic quantity of dried leaves amounting to less than 0.19 per cent of body weight.

Experimental feeding of western goldenrod (*Solidago spectabilis*) to sheep and cattle by the Nevada station showed that the active poisoning principle was not present in the leaves until late in the summer, and that up to August the plant may be grazed without danger.

In studies of fitweed (*Capnoides caseana*), dangerously poisonous to sheep and cattle on the range in the higher parts of the northern Sierra Nevada Mountains, the Nevada station observed symptoms in sheep fed as little as 1.5 pounds of the green plant, while quantities between 5 and 6.25 pounds caused death. No remedy is known for this poisoning, said to be caused by one or more deadly alkaloids, but it may be prevented by keeping sheep off the ranges in which the plant grows or by destroying the plant before pasturing.

In one instance as little as 500 grams of immature green bitterweed consumed in two days was found by the Texas station to cause the death of a sheep.

Death camas was found by the Wyoming station to be dangerous from the time it first comes through the ground until it becomes too dry to be edible, or on the Laramie plains from the first week in May until after July 15. Indications were that limewater given to poisoned sheep had a curative effect.

White snakeroot plants fed by the Ohio station to a Jersey cow at the rate of 3.5 pounds per day for 47 days resulted in no untoward symptoms during the period, nor did the milk from this cow when fed daily to rats, rabbits, a calf, and a lamb have any adverse effects.

The intravenous injection of freshly defibrinated normal bovine blood into cattle suffering serious hemorrhage due to sweetclover disease, the North Dakota station found, resulted in a large proportion of recoveries.

Parasites of the dog, fox, and mink.—The dog, the coyote, silver-black and blue foxes, the mink, the bobcat, the house cat, the brown bear, and both the eastern and Pacific raccoons may act as carriers of the parasite of salmon poisoning in dogs, although they do not develop symptoms of the disease, it was found by the Oregon station. Thus far the causative agent of the disease remains unknown. The station observed that a definite immunity follows an attack of the disease, but no practicable method of immunization nor medicinal treatment has yet been discovered. Well-drained sandy soil in fox pens infested with roundworms and hookworms was successfully disinfected by the Michigan station to a depth of 3 or 4 inches by spraying the soil with colloidal iodine and then flooding with water.

The lung fluke *Paragonimus kellicotti* occurs commonly in American mink and apparently is widely distributed, having been found by the Minnesota station in 7 of 84 carcasses examined.

Pullorum disease.—The New Hampshire station reported that losses from pullorum disease, which were as high as 60 per cent of all chicks hatched the year before the control work began in the State, had dropped to less than 0.5 per cent in the last three years as a result of the control work.

That ultimate eradication of pullorum disease can be accomplished only by testing at intervals of a month or six weeks and eliminating reactors until the flock is free from infection, is the conclusion of the California station after 10 years of blood testing of breeding fowls.

The agglutination test appeared from observations by the Ohio station to be more reliable than the intradermal test in detecting carriers of pullorum disease in mature fowls.

The intradermal test for pullorum disease was found by the Connecticut (Storrs) station to give results which very often failed to agree with those obtained through the two agglutination tests.

From studies of the dissemination of pullorum disease in incubators the Kansas station concluded that a humidity shown by a wet-bulb reading

of 95° F. at hatching time practically eliminated the spread of the disease. The hatchability of eggs, however, was 9.5 per cent lower than that for the hatches under optimum temperature and humidity conditions. A scale-like substance that surrounds small bundles of chick fluff on the newly hatched chick, and dust particles, were thought to carry the pullorum infection. Under favorable conditions of temperature and humidity all exposed pullorum organisms were destroyed within five minutes after formaldehyde had been liberated.

In a study of the hereditary resistance of chicks to pullorum disease, the Illinois station found a distinctly higher survival among those from matings of selected or resistant stock as compared with chicks from unselected stock.

Except in acute forms of pullorum disease in baby chicks, the Michigan station found a definite pathology upon which the disease can be diagnosed. An especially virulent strain of *Salmonella pullorum* isolated by the Massachusetts station from mature stock caused the death in 17 and 18 days, respectively, of two birds into which 0.2 cubic centimeter of broth culture was injected intravenously. Further evidence that brooder pneumonia in young chicks is the lung form of pullorum disease was reported by the Illinois station.

In studies of the incidence of pullorum disease in eggs from reactor hens the Rhode Island station concluded that there is no correlation between the percentage of infected eggs laid and the various phases of the clutch. Pullorum disease was found to spread rapidly from a group of infected birds to clean birds that ranged with them, in experiments at the New Hampshire station. That pullorum disease does spread among sexually mature fowls was the conclusion of the Minnesota station from experiments with nearly 100 fowls. The Rhode Island station reported that pullorum disease may be transmitted to healthy flocks through the feeding of eggshells as a source of lime. Evidence that the causative organism of pullorum disease remains viable on a dry piece of cloth in a flask for 14 weeks and possibly longer was reported by the Massachusetts station.

Seeking an efficient chemical disinfectant for the poultry yard, the Tennessee station found sodium acid sulphate to protect against pullorum disease infection when a 5 per cent solution was applied to the poultry yard at the rate of 1 gallon to 1 square foot of soil. At this strength it harmed neither the fowls nor the germination and growth of Italian ryegrass. It was pointed out that the sulphate corrodes metals, irritates the skin, is destructive to cloth, and should be handled with care.

A disease first recognized in a lot of chicks hatched in 1930 on a poultry farm known to be free from pullorum disease infection for the last seven years, from which approximately 20 per cent of the chicks died within the first week, was found by the Connecticut (Storrs) station to be due to an organism differing materially from that causing pullorum disease.

Fowl pox.—The use of a vaccine for fowl pox and similarly a bacterin for roup gave gratifying results at the Michigan station. The Johnson stick method of vaccination for fowl pox was found by the New Hampshire station to give better results than the older follicle method. Incisions varying from a stab to 0.25 inch were equally effective. The Kansas station found the feather-follicle and stick methods of vaccination against fowl pox to be preferable to subcutaneous injection of finely ground pox scabs. That healthy flocks can be immunized early in the fall against avian diphtheria, or fowl pox, with a minimum loss was demonstrated in field and laboratory experiments by the Illinois station.

Only 27 of 45,000 birds vaccinated in the field for fowl pox contracted the disease during the fall and winter months, in experiments at the Western Washington station. The results, according to reports from poultrymen, justified the use of vaccine on pullets between 3 and 4 months of age, some 22,000 fowls on 21 poultry farms having been vaccinated by the station during the summer of 1930.

Pigeon-pox vaccine was found by the Virginia station to be a very satisfactory immunizing agent for the prevention of natural infection with fowl pox, although the product prepared was not 100 per cent effective in immunizing against artificial infection. The pigeon-pox vaccine appeared to have no ill effects upon the birds and no decrease in egg production followed its use.

The vaccination of turkeys with fowl-pox virus at the Oregon station was highly successful. This station demonstrated a distinct resistance to fowl pox in chickens vaccinated 967 days previously. In one flock chickens vaccinated with fowl-pox virus dropped

drastically in production the third and fourth weeks afterward, while those in the same flock vaccinated with pigeon-pox virus dropped but slightly in production during the same period. The egg production of fowls vaccinated with pigeon-pox virus against fowl pox was higher than that of fowls vaccinated with fowl-pox virus. That fowl pox is transmitted to baby chicks by mosquitoes and may be prevented by screening the runs and houses was demonstrated by the Hawaii station.

Laryngotracheitis of the fowl.—Studies at the Illinois station at intervals during seven years of laryngotracheitis, a comparatively new infectious disease of the upper respiratory tract which has caused large losses, resulted in the isolation of a pleomorphic microorganism from laryngeal and tracheal exudates of both the acute and subacute or chronic forms of the disease. The subacute type of the disease, which has a low mortality, can be transmitted continuously from fowl to fowl by exudations from the larynx, but the acute and fatal form can not be.

The New Jersey stations reproduced infectious laryngotracheitis in healthy chickens by the intranasal or intratracheal instillation of infectious material. An active virus was obtained from filtrates and maintained its potency for 47 days in the dry state. It was demonstrated that the serum of a recovered bird possesses neutralizing properties and the bird is immune to subsequent infection with the organism.

Viruses from acute field cases of infectious laryngotracheitis were successfully propagated under laboratory conditions by the Massachusetts station and found filtrable. Immunological differences between acute and chronic cases were found in comparative studies of cases from Massachusetts, California, and New Jersey. The virus was demonstrated in the cloacal contents of infected fowls, and also in the tracheal exudate and in the secretions from the kidneys of diseased fowls. Some of the birds recovering from the disease were found to persist as apparently healthy immune carriers. The viability of the virus was found to be prolonged by freezing and drying.

The infectious nature of laryngotracheitis was definitely proved by the Western Washington station.

In a study of an outbreak of laryngotracheitis among fowls and pheasants in which the mortality was unusually high, the California station found a filtrable virus in the inflammatory exudate in the tracheas of infected fowls. The station concludes that the congestion of poultry ranches and the continuous brooding of chicks for replacements are the most important factors in the spread and continuation of this disease on such ranches.

Avian coccidiosis.—In a study of the causative parasites of coccidiosis of the fowl five of six species of coccidia occurring in poultry were produced by the Oregon station in pure culture. Two of the six were described as new, under the names of *Eimeria praecox* and *E. necatrix*, both of which attack the small intestine, beginning near the gizzard, serious infections of the latter producing marked hemorrhages and dilation of the intestine.

The reproductive bodies of avian coccidia kept in a refrigerator were found by the Ohio station when administered orally to 30-day-old chicks to be infective after two years of storage. In testing the duration of outdoor infectivity of coccidial material, droppings from infected fowls scattered over the surface of an inclosure in July produced a high mortality in chicks 30 to 40 days old, placed in the pen at different times during the following four months.

The mortality in chicks inoculated with coccidia was reduced from 65 to 5 per cent, in experiments at the Pennsylvania station, by keeping the feed free from the droppings. It was found that frequent removal of the litter reduced mortality. Wire floors were also found to be of assistance in reducing mortality from coccidiosis.

The infective stage of coccidia in chick brooder houses and rabbit hutches was found by the Michigan station to be destroyed by scrubbing with colloidal iodine. An improvement in the condition of birds was brought about by feeding small quantities of colloidal iodine daily.

The incorporation of 15 per cent powdered buttermilk in the daily feed gave a fair degree of control of coccidiosis in experiments at the Michigan station. The addition of 30 per cent of powdered buttermilk to the starting mash of 2,000 range chicks checked the disease mortality and hastened recovery.

Fowl paralysis.—Examinations by the Montana station of birds in 32 flocks suffering from leg weakness showed either tapeworm or roundworm infestation to be the direct cause of the trouble. The treatment of tapeworm-infested flocks with 1-gram kamala tablets brought about almost immediate relief, and the use of 1-cubic-centimeter

capsules of tetrachlorethylene was equally effective in the case of roundworm infestation.

That some of the outbreaks of so-called range paralysis of poultry are caused by or associated with coccidiosis was the conclusion reached by the Michigan station.

Ninety-five per cent of the paralytic birds examined at Petaluma were found by the California station to be affected with chronic coccidiosis. The feeding of 40 per cent milk mash was found by the station to be of benefit only to those flocks in which diagnosis of chronic coccidiosis was made early.

Other avian diseases.—A sporadic disease of pullets characterized by leg weakness, loss of appetite, partial paresis, emaciation, and diarrhea, followed by death, was found by the Illinois station to be an unusual form of fowl cholera.

In a search for an internal disinfectant for poultry the Rhode Island station found metaphen to act as an efficient disinfectant of drinking water in a 1:20,000 dilution. When administered by mouth in a 1:500 dilution it was nontoxic for baby chicks but did not appear to have any germicidal action in the alimentary tract.

Records kept by the Michigan station for eight years indicate that nearly one-fifth of the pullets die during the first year of egg production.

An extended study in which material from 227 cases of human tuberculosis was typed by the Nebraska station furnished no evidence that the bacillus of avian tuberculosis is a cause of tuberculous disease in man. On the other hand, the prevalence of avian tuberculosis on farms must be looked upon as a positive hazard to other livestock.

A disease in day-old chicks from incubators in commercial hatcheries, resembling navel infection in other animals, was found by the Kansas station to be associated with insanitary methods during incubation. In experiments with formaldehyde fumigants at least three times the quantity of ingredients necessary for destroying the pullorum disease organism was required to destroy the spore forms of the anaerobe and a mixture of organisms from superficial tissues.

Outbreaks of a disease in chicks from 10 to 20 days of age in which a sudden onset of symptoms of pulmonary dyspnea accompanied by great depression was followed by death in from three to four hours, appear to have been due to an acute generalized colibacillosis, according to the Kansas station. There was an average mortality of 4 per cent in the 49 outbreaks encountered.

An apparently new acute and quite fatal respiratory disease of baby chicks was reported by the North Dakota station to have been common in that State in April, 1930; it appears to have occurred in other States as distant as Mississippi and Louisiana. It is described as an acute and highly contagious disease of chicks of from 2 days to 3 weeks of age, of which the large majority manifested the first symptoms from five to nine days after hatching.

Blackhead.—Further work by the Connecticut (Storrs) station with blackhead of turkeys supported the earlier conclusions that weekly ground rotation is an important means of reducing blackhead mortality to a low and insignificant rate. The results emphasized the advisability of allowing the ground to rest during the winter and spring months. Additional evidence that chickens are important carriers of blackhead was obtained. The administration of colloidal iodine was found by the Michigan station to aid materially in the control of the disease. The use by the Michigan station of colloidal iodine gave encouraging results for the prevention and cure of blackhead of the turkey and also gave promising results in the control of coccidiosis in poultry and the large tapeworm of the turkey.

Parasites of poultry and their control.—The Michigan station found that a 2-ounce dose of colloidal iodine containing 2 per cent of iodine, 4 per cent of gum arabic, and 2 per cent of ferric chloride, when administered into the gizzard with a turkey-dosing appliance, was wholly efficient in killing and removing the large tapeworms even when they were present in large numbers.

Powdered kamala and a colloidal iodine preparation were found by the Oregon station to be of less value than sanitation in combating the tapeworm *Davainea proglottina*. Kamala administered to chickens at the Ohio station had no visible effect in doses up to 8 grams, but a pronounced diarrhea and general depression were observed in all treated birds, followed by death in from 1 to 10 days in all but 4 of the 18 birds to which doses of 9 and 10 grams had been administered. In the doses used, from 7.5 to 15 grains, it was not highly efficient for the removal of tapeworms from chickens.

High temperatures and low humidity were found by the Kansas station to

be the most potent factors acting against the survival of the eggs of the intestinal roundworm of poultry (*Ascaridia lineata*). Low temperatures, from —10° to —20° F., were lethal to the roundworm eggs in most cases. Roundworm eggs on the surface of the soil do not survive the entire winter, but those deposited in late February survive and develop slowly, reaching the infective stage in late April or early May in time to be eaten by the second brood of baby chicks.

Carbon tetrachloride was found by the Kansas station to be effective and safe for control of the intestinal worm, *A. lineata*, when used in a dosage rate of 4 cubic centimeters per kilogram of body weight. This station observed that the roundworm of chickens (*A. lineata*) does not require vitamins A, B, or D during the first third of its growth. The resistance of growing chickens to this roundworm was found to be lowered when fowls from 4 to 7 weeks old were kept for five weeks on a diet deficient in vitamin A. When the diet of chickens that had been given the same number of embryonated worms was lacking in vitamin B they were more highly parasitized by the intestinal roundworm than were chickens whose rations contained adequate amounts of this vitamin. Since larger numbers of this roundworm were found in chickens whose diet contained yeast than in the groups whose rations lacked it, it is thought that yeast may contain a factor favorable to the growth of the worm.

A colloidal iodine suspensoid administered in vermicidal doses was found by the Michigan station to be 100 per cent effective in killing and removing ascaridia and the various species of tapeworms, without affecting egg production, thus offering a substitute for a proprietary remedy with a possible reduction in cost of about 33 per cent. A marked improvement in the birds' condition may be brought about as a result of daily feeding of colloidal iodine to birds in excess of the normal iodine requirements in cases of intestinal parasitism, either worms or coccidia.

Capsules loaded with an insoluble powdered colloidal iodine, which gives off the iodine slowly by diffusion after the insoluble particles swell, developed by the Michigan station, were fairly efficient in removing intestinal roundworms and tapeworms in chickens and turkeys.

In a study of the effect of various concentrations of nicotine on the growth and development of baby chicks by building up in them a tolerance to tobacco, the Pennsylvania station found it possible to feed them for 16 weeks on a ration containing as much as 1.2 per cent of pulverized tobacco, with a 5 per cent nicotine content, with no harmful effects.

The Western Washington station reported having found the capillaria parasite (*Capillaria annulata*) to be a rather common parasite of the Hungarian partridge and when present in large numbers to cause the death of the infested bird.

The Minnesota station accumulated evidence pointing very definitely to the nymph of the dragon fly as the second intermediate host of the fluke parasite of poultry, *Collyriclum faba*.

The use of a powdered orthophenylphenol by the Michigan station caused poultry lice on feathers to drop off quickly and die in from 5 to 10 minutes even when this preparation was highly diluted with talc or fuller's earth. The dust remained effective on birds for about five days.

Nicotine sulphate, the Kansas station found, can safely be used to eradicate the feather mite of chickens by applying it to the roost without the necessity of handling individual birds. The New Jersey stations found that a 1 to 10 dilution of 40 per cent nicotine destroys the feather mite when sprayed on the feathers on the underside of the body of the fowl.

WILLIAM A. HOOKER.

FOODS AND HUMAN NUTRITION

Experiment station research in foods during the year was concerned with developing new methods and improving old methods of preserving, using, and preparing for the table foods of regional economic significance; with studies of the effects on food composition, particularly vitamins, of variations in production and handling methods; and with analyses of common food materials for their contents of the essential inorganic elements, iron, copper, and manganese, which are found in such small quantities in foods as to be called "trace" elements. Nutrition research included laboratory studies on rats and other experimental animals to determine the nature and function of the vitamins and the significance in nutrition of the trace elements, and growth and metabolism studies on human subjects with a view to establishing normal standards of comparison. A few of the more significant contributions of the

year are noted briefly below and, with others, are discussed in greater detail in the sections which follow.

The introduction of quick freezing as a method of food preservation has opened up a considerable field for investigation in which the experiment stations have been active during the year.

Practical suggestions for preventing spoilage in frozen fruits and berries in small containers were contributed by the Oregon station. The station recommended that to accomplish the best results the fruit be handled promptly, packed in vacuum-closed containers, precooled, stored in the cold until freezing, and frozen at very low temperature.

Danger of spoilage in the thawing of quick-frozen foods received attention at the California station. Observations of the rate of spoilage of non-acid fruits and vegetables after being thawed showed that the organism responsible for botulism, if present in the original material, is not destroyed by the freezing process. For this reason great care in distributing frozen foods is urged by the station.

A satisfactory process for freezing native figs was developed by the Georgia station. The secret of retaining the original color and delicate flavor lay in the slow freezing at 0° F. rather than the very rapid freezing at much lower temperature which gives the most satisfactory results with peaches.

The cooperative meat investigations of the experiment stations and the Department of Agriculture have led to the development of standard methods of roasting meat; using thermometers inserted in the meat. This does away with guesswork in roasting to the desired degree. Directions for roasting beef with the use of these thermometers were published by the North Dakota station. For housewives who possess oven thermometers but not meat thermometers, time-tables were also given, showing how long to cook roasts at certain oven temperatures to obtain the desired state of doneness. (See also p. 75.)

Comparing the palatability of roasts from beef animals of different ages cooked by the standard procedure with the use of meat thermometers the Iowa station found that the roasts from steers 20 to 30 months old had the most desirable flavor.

A satisfactory method of roasting beef without a preliminary searing was developed by the Missouri station and found to be applicable to some of the less tender cuts of beef. This method also calls for meat thermometers for the best results.

Standard recipes for baking different types of flour mixtures at altitudes ranging from sea level to 11,180 feet were published by the Colorado station as the result of actual baking tests in an "altitude laboratory" where the atmospheric pressure could be changed at will to correspond to different altitudes.

Practical methods of using soft-wheat flour were reported during the year by the Illinois station, of cooking pinto beans by the New Mexico station, and of baking pears by the Oregon station. These are of importance in their effect upon consumer demand for locally produced foodstuffs.

Increased consumption of turnip greens should result from studies reported by the Georgia station showing that these greens, available in the South throughout the year, are unusually rich in vitamin C, comparing favorably with oranges even after being cooked or canned. Canned asparagus also ranks high in vitamin C according to the South Dakota station. Tomato juice, now a popular source of vitamin C, is also rich in vitamin A, but to retain its vitamin A content should not be filtered, for the Wisconsin station found that an unfiltered commercial tomato juice had over thirty-one times as much vitamin A as the same juice after filtering. The feasibility of adding vitamin D to tomato juice and to butter through irradiation was demonstrated by the Wisconsin station.

Locally grown dates processed in the customary manner were found by the Arizona station to be a good source of vitamin B, a fair source of vitamin A, but to lack vitamins C, G, and D.

Apricots were found by the California station to be so rich in vitamin A that although there was considerable loss during the customary drying processes, the final product is still a good source of this vitamin. Treatment of peaches, apricots, and prunes with sulphur dioxide during drying tended to protect the vitamin C in the fruit from the destruction that invariably takes place in fruit dried without sulphuring.

Further evidence that copper alone is essential as a supplement to iron in preventing and curing simple nutritional anemia in laboratory animals was reported by the Wisconsin and Ohio stations, and good results were

noted in similar treatment of certain forms of human anemia in hospital practice.

The presence of small amounts of fluorine in the drinking water of certain localities was found by the Arizona station to be responsible for the development of a disfiguring condition of the teeth known as "mottled enamel."

The importance of these "trace" elements in nutrition, either as beneficial or harmful agents, has led to the development of sensitive methods for their determination and to analyses of food materials and water for their quantitative occurrence.

The question whether pellagra is caused by a vitamin deficiency received considerable attention at several of the stations. Symptoms strikingly like those of human pellagra were produced in rats at the Wisconsin station by diets containing a very high proportion of egg white and were cured by feeding relatively large amounts of liver or yeast. These findings are of particular interest theoretically in suggesting that egg white may contain an antivitamin or something which counteracts the effects of vitamins, and practically in offering a possible explanation of the sensitiveness of some children to eggs manifesting itself in a type of eczema.

Although many problems in human nutrition can be solved in the laboratory with rats as the experimental animals, some investigations still require human subjects. Two studies of this type reported during the year are of particular interest. One, made by the Ohio station, was on the seasonal growth of preschool children; the other, reported by the Oklahoma station, was on the basal metabolism of young women of college age. An important conclusion of the Ohio study was that although young children do tend to gain more in weight in summer than in winter, more attention to regular habits in the winter than in the summer, particularly sufficient rest during the day, may reverse the relative weight gains of the two seasons.

The basal metabolism values obtained in the Oklahoma study were universally low in comparison with the usual standards, thus emphasizing the inapplicability of present standards to women in all sections of the country and the necessity of establishing standards for various sections, based upon a large number of records obtained from normal subjects in each section.

FOOD PRESERVATION, UTILIZATION, AND PREPARATION

Between the production of foodstuffs and their ultimate consumption are many problems which require attention. Perishable foods must be preserved until they can conveniently be consumed; new ways of utilizing foods must be discovered to increase consumption demands; and to the same end existing methods of food preparation must continually be improved. Among the experiment station contributions along these lines are the following:

Preservation and utilization of the Hawaiian avocado.—On account of the embargo on exportation of fresh avocados from Hawaii, methods of preserving and utilizing the fruit were studied by the Hawaii station. Efforts to preserve the fruit by processing were handicapped because a quinine-like, bitter principle developed on heating the fruit, and undesirable changes in color and texture took place. Although ordinary canning methods proved unsatisfactory, it was found that when avocado cubes, halves, or slices were soaked in pineapple vinegar until penetrated by the liquid and then removed from the vinegar and processed at 212° F. for at least 10 minutes, or 160° for 20 minutes, the natural color destroyed by the soaking process was restored and the flavor was not undesirable.

A satisfactory product was obtained by combining the avocados thus treated with an equal amount of canned crushed pineapple to which fruit spices siruped with a 50 per cent sugar solution had been added, exhausting the mixture for 10 minutes and processing it for 30 minutes at 160° F. Avocado cubes and halves stored at temperatures of from 0° to 20° in diluted brines, vinegar, sirups, and water, in receptacles tightly sealed to prevent oxidation, did not retain their original texture on thawing but were of satisfactory color and flavor. A satisfactory pulp for use in ice cream was made by mixing 1 part of sugar with 5 parts of pulp and storing the mixture in sealed containers at 0°.

Food preservation by frozen storage.—Problems in preserving food by freezing it at low temperatures continued to receive attention at several stations. The Oregon station reported the results of studies conducted in 1928, 1929, and 1930 to determine the best methods of reducing or eliminating spoilage in frozen fruits and berries in small con-

tainers. Recommendations for future practice, based upon these studies, included prompt handling of the fruit, the use of vacuum-closed containers, and precooling and storing the berries in the cold before freezing them at very low temperatures. Suggestions on varieties of berries best adapted to freezing, the type of sugar giving the best results, and the densities of sirup for different berries were given.

The use of 40 to 60 per cent sugar sirups was found by the Massachusetts station to give better results in quick-freezing fruits for use in ice cream than the use of dry sugar formerly recommended by the station. Invert sugar sirups gave no better results than sucrose, and cane sugar was distinctly unsatisfactory.

Preserving figs in freezing storage was reported upon during the year by the Georgia station. Slow freezing at 0° F. proved more satisfactory for figs than quick freezing at from —50° to —100°, noted in the 1930 report as the most satisfactory for peaches. This suggests that general directions for freezing can not be given, but that each fruit or vegetable must be studied separately. Lists of the kinds and varieties of fruits, vegetables, and juices frozen at the Georgia station during the last five years, arranged according to adaptability to freezing, the media in which the fruits and vegetables were frozen, and the kinds and sizes of containers used, have been made available.

The freezing and thawing of frozen-pack fruits and vegetables were studied at the California station with the conclusion that the heat transfer in these processes takes place chiefly by conduction rather than by convection and consequently is relatively slow. Among the more important factors found to affect the rate of freezing and thawing were the size, composition, and shape of the container, the conductivity of the product, and the temperature of the surrounding space. Heat transfer was found to be more rapid in sirups of high than of low density. Observations on the spoilage of nonacid fruits and vegetables after thawing showed the possibility of growth of *Clostridium botulinum* during prolonged standing at room temperature. For this reason the necessity of great care in distributing frozen foods was emphasized.

Meat cookery.—Studies have been carried on at several experiment stations, cooperating with the Department of Agriculture, to determine the most satisfactory methods of roasting meats and the effect of various factors upon the palatability of meats roasted by standard methods. The method of roasting recommended by the national committee was followed by the Iowa station in comparisons of the palatability and cooking losses of roasts from animals of different ages, of roasts ripened for varying lengths of time, and of roasts from feeder and fattened carcasses. The roasts from calves (baby beef) showed higher volatile losses than those from the older animals and practically the same total cooking losses from the feeder as from the fattened animals. In texture the roasts from the calves scored slightly higher than those from the yearlings, or 2-year-olds; in tenderness there was not much difference; and in juiciness the roasts from the calves scored lowest. Ripening improved the palatability of the roasts from the fattened calves more than it did those from the yearlings and 2-year-olds, but the flavor of the roasts from calves even after ripening was rather flat and insipid. It was concluded that to produce beef for roasts having the most desirable beef flavor, steers should be at least 20 and preferably 30 months old.

The temperature changes taking place in standing beef roasts during roasting at different oven temperatures and after removal from the oven, and the effect of these changes upon the doneness and quality of the roast were determined by the North Dakota station. The roasts were first seared for 20 minutes in an oven kept at a temperature of 250° C. and then roasted at temperatures varying from 110° to 175°. When the roasting temperature was 125°, removal of the roasts when the internal temperatures were 51°, 61°, and 71° was found to give ideal rare, medium, and well-done roasts, respectively. Temperatures of 110° and 125° gave greater uniformity of doneness than higher temperatures and with smaller losses. Practical directions for roasting beef, based upon the findings in these studies, have been issued. These include time-tables for cooking roasts of varying weights to rare, medium, or well-done stages.

A satisfactory method of roasting beef without the customary searing at high temperatures was developed by the Missouri station. A constant oven temperature of 110° C. produced the smallest cooking losses and the greatest uniformity in most ovens. Temperatures of 125° and 165° were both satisfactory, although the lower temperature is considered slightly supe-

rior. For a medium-rare stage of doneness the roasts were removed when the internal temperature registered 57° and for a well-done stage they were removed at 70°. Roasting at either of these constant temperatures also proved fairly satisfactory for certain less tender cuts of beef.

Altitude cookery.—Time-tables for boiling, steaming, and baking various vegetables at an altitude of over 7,000 feet have been published by the Wyoming station. The Colorado station has reported on baking studies conducted in the altitude laboratory in which the barometric pressure can be changed to correspond to that of any altitude from below sea level to 14,000 feet above it. The types of flour mixtures selected for the investigation included mixtures leavened by the expansion of steam, illustrated by pop-overs and cream puffs; mixtures leavened by carbon dioxide, including baking powder biscuits, muffins, and other quick breads and butter cakes; and mixtures leavened by the expansion of air, including sponge cake and angel cakes. For each of these types of flour mixture standard recipes were developed for various altitudes from sea level up to 11,180 feet. These recipes were checked not only in the altitude laboratory, but also in various localities where the actual altitudes corresponded with the experimental conditions of the laboratory.

Local problems in experimental cookery.—Food laboratories at the experiment stations are often called upon to carry on projects of more or less service character, as for example to develop improved methods of cooking certain locally produced foodstuffs with a view to increasing the consumption of these materials or to test the effect of cultural practices on culinary qualities.

Studies of various methods of cooking pinto beans were reported from the New Mexico station. Standard recipes for baking pears were developed at the Oregon station. Studies of the baking and chemical qualities of soft-wheat flours grown in Illinois were continued by the Illinois station, with the conclusion that these flours can be used in place of either hard bread flour or a fancy cake flour. Studies at the Rhode Island station on the relation between potash fertilization of the soil and the culinary value of potatoes led to the conclusion that potatoes grown in soil with high potash fertilization are more mealy when cooked than those of the same variety grown on soil of low potash content, and, further, that muriate of potash is slightly more effective than the sulphate.

In judging the quality of cooked foods the customary criteria are purely subjective, a committee of judges checking descriptive adjectives on appropriate score cards. The Maine station is devoting some attention to the development of objective tests and has reported a standardized procedure for determining doneness in cooked vegetables by using an adaptation of a commercial penetrometer.

FOOD COMPOSITION

Studies of the vitamin content of foods of local importance and of the effect upon vitamin content of various factors in the production and manipulative treatment of foods again lead among food-composition studies. Interest in the function of iron and copper in nutritional anemia, and of manganese as essential for growth and reproduction, has led to further studies of the distribution of these elements in foods. Since they occur in natural foods in very small quantities, the development of improved technic for their determination has been necessary.

Hawaii-grown oranges were found by the Hawaii station to indicate about the same content of vitamin C as California-grown oranges. Native-grown tomatoes were found to be richer in vitamin C than similar tomatoes grown on the mainland. This difference was attributed to the fact that the Hawaii-grown tomatoes were probably riper when picked than those picked in California for shipping to Hawaii. Marked seasonal variations were found in the vitamin A content, but not in the vitamin B complex content of raw peas grown during three successive seasons at the Michigan station. About six times as much of the raw peas of the 1927 crop and twice as much of the 1928 crop as of the 1929 crop was required to produce corresponding growth in experimental rats in the vitamin A studies.

The effect of light of various qualities upon the development of vitamin A in the growing plant was studied at the Michigan station. Asparagus was grown under four glass filters of known limits of transmission, and also in the open air and in the open but covered with soil to prevent access of light. The tips of samples thus grown were analyzed for various constituents and for their content of vitamin A. Of the factors studied, the content of

chlorophyll showed the closest relationship to vitamin A. The possibility was suggested that chlorophyll is a sensitizer of vitamin A and consequently a limiting factor in the synthesis of this vitamin in the vegetative parts of the plant.

Earlier studies on the distribution of the vitamin B complex in the structural parts of the corn kernel were repeated by the Illinois station with the newer technic for vitamin B (B_1). As has previously been shown to be true for the vitamin B complex, vitamin B (B_1) was found to be concentrated almost entirely in the germ and thus lost to human consumption in the customary corn-milling products. The relative concentration of vitamin B in the different cereal grains was also studied at the Illinois station. The amount of corn, as the sole source of vitamin B, necessary to produce maximum growth was from 40 to 45 per cent and of wheat from 50 to 55 per cent of the ration. In a similar study on oats in another laboratory at the station, normal growth was secured when the oats constituted 35 per cent of the ration. Apparently oats is the richest of the three cereals in vitamin B, followed by corn and then wheat.

The widespread use of tomato juice has raised the question of the relative richness in vitamin content of various commercial products. The Wisconsin station found that a high-grade commercial juice was not only relatively rich in vitamin A, but contained about thirty-two times as much of this vitamin as the clear filtered serum from the juice. This suggests that too clear a product is not to be desired. The unfiltered commercial product contained no appreciable amounts of vitamin D, but the feasibility of fortifying it by adding irradiated ergosterol was demonstrated, since no loss in vitamin D potency in juice fortified in this way could be observed after storage for 13 months.

The feasibility of fortifying butter with vitamin D either through irradiation of the butterfat or through the addition of irradiated ergosterol also received attention at the Wisconsin station. It was found possible to increase the antirachitic properties of June butterfat about twenty times through suitable irradiation. This was done, however, at the expense of a considerable loss in vitamin A. There was no further loss of vitamin A or antirachitic activity of the butterfat on prolonged storage. The addition of 10 milligrams of irradiated ergosterol to each pound of butterfat increased the antirachitic activity of the butter eighty times, making the product twice as potent as cod-liver oil. Although this activation was excessive, the practical possibilities in increasing the vitamin D content of butter in this way were considered to have been demonstrated. In commenting upon increasing the antirachitic activity of foodstuffs by the incorporation of activated ergosterol the Wisconsin investigators emphasize the necessity of strict control. They consider that the problem of how best to furnish a sufficiency of vitamin D (whether by direct or indirect activation) is not yet settled, but that the practical fortification of the human diet in vitamin D offers no essential difficulties.

Studies on the effect of canning upon the vitamin A and C of various foods have shown that canned vegetables need not be shunned through fear of loss of vitamin A or too great loss of vitamin C and that certain relatively inexpensive foods either in the raw or canned state are good sources of vitamin C.

Peas canned by blanching for five minutes and processing at 15 pounds pressure were found by the Michigan station to suffer no loss in vitamin A, but a loss of from 30 to 45 per cent in vitamin B complex.

Turnip greens and collards were likewise found by the Georgia station to show no losses in vitamin A when canned by the usual commercial methods. Turnip greens were very rich in vitamin C, comparing favorably even after cooking or canning with oranges, one of the best sources of this vitamin. Collards, although not so rich in vitamin C as turnip greens, retained appreciable amounts of the vitamin after the long cooking period common for this type of greens.

Other canned foods tested for vitamin C content during the year were canned spinach, reported by the Missouri station to be only about one-fifth as rich in vitamin C as raw spinach; home-canned Swiss chard, found by the South Dakota station to be quite valueless as a source of vitamin C; and commercially canned asparagus, reported by the South Dakota station to rank high in vitamin C content of both stalks and juice.

Three varieties of dates grown at the University of Arizona date farm and prepared as for marketing by the usual manner of processing were tested by the Arizona station for content of known vitamins. The varieties tested

were the Maktum, a soft fresh date high in invert-sugar content; the Deglet Noor, a semidry cane-sugar variety; and the Thoory, a representative dry date, sometimes called a bread date. No measurable amounts of vitamins C, G, or D were found in any of the dates. The Thoory ranked highest of the three varieties in vitamin A, although the value for the Maktum was the same when calculated to a dry basis. The Maktum ranked slightly higher than the other two in its content of vitamin B (B_1). The unit values for all three varieties, in comparison with those previously reported for other foods, indicate that dates are not particularly valuable as a source of vitamin A, but constitute a good source of vitamin B.

So much emphasis has been placed upon the probable destruction of vitamins A and C by manipulative processes that an investigation by the California station into the effect of drying and sulphuring upon the content of vitamins A and C in such dried fruits as peaches, apricots, and prunes is of interest. In the fresh-frozen state all three of these fruits proved to be relatively high in vitamin A. Particularly was this true of apricots, the reports on which were said to compare favorably with the best figures reported for spinach, egg yolk, or butter. Wide variations in the stability of vitamin A in the three fruits to the various drying processes were apparent. The peaches lost little of their vitamin A in any of the drying processes and the prunes from about 9 per cent in the dehydrated sulphured to over 75 per cent in the dehydrated nonsulphured products. Apricots lost an even higher percentage of their vitamin A content, but the original content was so high that the least successful of the drying processes yielded a product richer in vitamin A than the best of the peach and prune products. In the vitamin C studies, the results obtained with both apricots and prunes confirmed earlier studies on peaches in showing that sulphur dioxide tends to preserve the vitamin C content of fruits on drying and that a certain minimum of sulphur dioxide is required to insure this protection.

In view of the rapidly growing use of frozen storage for preserving fruits and other foodstuffs, it is of interest that in the California study fresh apricots ground, packed in 8-ounce tin cans without evacuation, and frozen solid, afforded no protection against scurvy in guinea pigs in doses of over 30 grams daily, while samples frozen in tins from which the air had been removed afforded complete protection in 15-gram daily doses. No such destruction was noted in the frozen prunes which were effective in doses of 10 to 20 grams daily, nor in frozen peaches. The Georgia station, however, reported a very low content of vitamin C in frozen peaches of the Elberta and Hiley varieties stored for six or seven months at temperatures below the freezing point. A new field of research in vitamin content has been opened up through the introduction of quick freezing as a method of preserving foods. An investigation of the effect of this process on the content of vitamins A and G in milk has been undertaken at the Georgia station.

The iron, copper, and manganese content of foods.—In connection with the nutritional anemia studies noted on page 79, the Mississippi station developed an improved technic for determining iron in food materials and analyzed for iron a number of plant materials in the raw state and after cooking by various methods. Separate analyses of the stalks and leafy portions of mustard, turnip, and collard greens showed that the leafy portions were from four to seven times as rich in iron as the stalks. The green outer leaves of cabbage were found to contain from 35 to 100 per cent more iron than the inner bleached leaves. On cooking, the greatest losses in iron took place when the materials were cooked for a long time in a large amount of water (the common method in that section of the country) and the smallest losses when steamed or cooked for a short time in a pressure cooker.

Wide variations in the copper content of livers from different animals were found by the Kentucky station. Calf, lamb, and steer livers were approximately ten times richer in copper than hog, pig, horse, or chicken livers. The livers containing the smaller amounts of copper had slightly larger amounts of iron and manganese than those containing the larger amounts of copper.

The possibility, as noted on page 79, that manganese may be an essential element in nutrition has aroused interest in its distribution in food materials. Analyses recently published by the Wisconsin station showed that cereals probably contribute most to the supply of manganese in the diet, and are followed by fruits and vegetables. Cereals were also believed to supply the largest proportion of copper, and with vegetables to be the chief contributors to the iron supply. Fruits

are important sources of all three of these essential elements. A diet considered adequate for a workingman with respect to the food constitutents for which standards have been established was calculated to furnish 8.41 milligrams of manganese, 4.81 milligrams of copper, and 36.12 milligrams of iron—exceedingly small amounts in comparison with the daily requirements for protein, fat, and carbohydrate.

NUTRITION INVESTIGATIONS

A yearly report of nutrition investigations is read to best advantage in connection with the report of the preceding year, for in general such investigations cover a period of several years. This is true of the studies on the rôle of certain mineral elements in nutrition, and to an even greater extent of vitamin research, for although 20 years have elapsed since the pioneer investigations of the Connecticut State and Wisconsin stations which contributed so much to knowledge of the existence of vitamins as essential food constituents the chemical nature and functions of vitamins are not yet clearly understood.

The rôle of copper, iron, and manganese in nutrition.—The theory first advanced by the Wisconsin station that copper is specific as a supplement for iron in the prevention and cure of what is known as simple nutritional anemia, produced in rats by prolonged milk feeding, received definite confirmation at the Ohio and Iowa stations in studies showing that manganese, which had been considered by some investigators to be likewise effective, was valueless for hemoglobin regeneration either alone or in combination with iron.

A practical outcome of the discovery of the relationship of copper to iron in the treatment of nutritional anemia in rats has been the introduction of similar treatment of human anemias. Preliminary investigations in child-health centers in Wisconsin have given confidence that certain secondary anemias in infants will respond to treatment with copper and iron salts, and it has been reported from the General Hospital at Montreal, Canada, that in several long-standing cases of anemia in adults immediate improvement occurred following the use of copper salts as supplements to iron therapy which previously had been ineffective. This close relationship between certain types of anemia in human beings and the nutritional anemia so readily produced in rats by milk feeding has made worth while the study of various foods for their effectiveness in treating nutritional anemia in rats.

Sorgo and sugarcane sirups, used so extensively in certain sections of the country, were found by the Mississippi station to be effective in the regeneration of hemoglobin in rats, but not so effective as liver fed at the same level of iron. The sorgo sirup was rather more effective than the sugarcane sirup fed at the same iron level, although the latter had a slightly higher content of copper. Mustard and turnip greens were found to be quite effective.

Although manganese seems to have been ruled out as essential for blood formation, studies conducted on rats and mice at the Wisconsin station showed that it is probably essential to growth and successful reproduction. In rats the chief storage organ of manganese from an ordinary stock diet was found to be the liver, which contained 6.15 milligrams of manganese per kilogram. In animals fed additional manganese the concentration was still highest in the liver, although the percentage increase in this organ was not so great as in the bones and hide, which normally contained very little manganese. Mice maintained on a diet of milk fortified with iron and copper grew much more rapidly when the diet was supplemented with small amounts of a manganese salt, and the females reproduced more normally. This indicates that milk is naturally deficient in manganese. Attempts to increase the manganese content of cow's milk by feeding additional manganese were unsuccessful.

Mottled enamel.—That traces of certain elements may be injurious rather than beneficial was illustrated most strikingly during the year by the announcement of the Arizona station that mottled enamel, a disfiguring and destructive condition of the teeth endemic in certain sections of that State and in other parts of the country, had been traced quite definitely to excess fluorine in the drinking water, although the quantity present in the water of localities in which the condition was endemic did not exceed 7.5 milligrams per liter—a concentration requiring very sensitive methods to determine.

In the community in which the Arizona investigation was first undertaken it was found that practically every person who was born and reared in that locality or who had come there in the early years of life, suffered from mottled enamel, while all who were

born where the condition was not endemic and who had come to the community after their permanent teeth had erupted were entirely free from the defect. Analyses of the drinking water in various communities showed a fluorine content not exceeding 0.3 milligram per liter in localities where mottled enamel did not exist, and from 3.8 to 7.5 milligrams per liter in the community where it was so prevalent. When some of this drinking water was concentrated and given to laboratory rats as their only drinking water a tooth condition analogous to mottled enamel developed, and this also happened when the rats were given small amounts of a salt of fluorine in their drinking water or food. This study seems worthy of special note, for while drinking water has long been suspected to be the cause of mottled enamel, the nature of the harmful constituent had not been determined hitherto.

Vitamin research.—Whether pellagra is a vitamin-deficiency disease is an important economic question on account of the prevalence of this disabling condition in certain sections of the country and the need of more exact knowledge concerning its dietary treatment. For this reason studies of the factor commonly called vitamin G are of particular importance. During the year evidence published from several stations led to the conclusion that two factors are involved in vitamin G, one of which is essential to growth and the other to the prevention of pellagra-like symptoms in rats. Whether these symptoms are identical with those of human pellagra is still an open question.

The theory that pellagra in human beings and blacktongue in dogs are caused by an iron deficiency rather than a vitamin deficiency was investigated by the Michigan station with reference to the pellagra-like symptoms in rats, with the conclusion that an iron deficiency is in no way responsible for the rat dermatitis developing with the customary vitamin G-deficient diet. It is of interest in this connection that the Arkansas station, in an investigation of the effect of various vitamin deficiencies on the composition of the blood, reported marked anemia in rats in which skin lesions had developed on diets deficient in vitamin G, but containing an abundance of iron. Anemia was not encountered in rats on diets deficient in vitamin A or D.

An important investigation which may ultimately throw some light upon the problem of human pellagra, although its primary purpose was to study the physiological effects of diets rich in egg white, is in progress at the Wisconsin station. Young rats weaned from a stock diet and placed on a diet containing egg white to the extent of 66 per cent, together with dried yeast, wheat embryo, sugar, and a salt mixture, rarely survived more than a few days. Rats which had come from stock on the same diet supplemented with dried cooked beef liver were, for the most part, able to survive the first acute injury, but later developed skin and nerve symptoms strikingly like those of human pellagra. These symptoms could be prevented or cured by 20 per cent of dried beef liver, but not by smaller amounts. These findings suggest the presence in egg white of a toxic substance (possibly an antivitamin) which becomes effective when large quantities of the material are fed, but can be neutralized by correspondingly large quantities of foods rich in the protective vitamin. If this is the case, care should be taken to provide protective foods whenever large quantities of egg white are prescribed in the diet or when eggs are first introduced into the diet of young children.

The idea that foods may contain antivitamins as well as vitamins is becoming more prevalent. The suggestion originally made by an English investigator that cereals contain what might be called an antivitamin D, or a factor interfering with the normal deposition of calcium in the bones, received support at the Wisconsin station where it was found that the calcifying properties of rolled oats, wheat, corn, and rice were improved by cooking and even more by subjecting them to more drastic heat treatment such as is employed in manufacturing puffed wheat and puffed rice. The decalcifying factor or antivitamin appears to be present in large quantities in wheat-germ oil and in wheat gluten.

Evidence of the existence of an antivitamin for vitamin E was first advanced by the California station and recently confirmed by the Wisconsin station. This antivitamin is considered not to destroy vitamin E, but simply to render it ineffective.

The effect of vitamins upon various metabolic functions continued to receive attention at various stations. From determinations of the coefficients of digestibility of proteins, fats, and carbohydrates in rats on a complete ration and on rations deficient in vitamins A, B, G, and D, respectively, and from similar determinations with

guinea pigs on complete and vitamin C-deficient diets, the Oklahoma station concluded that digestion is not influenced by the presence or absence of these vitamins.

The theory that fat exerts a sparing action on the antineuritic vitamin B (B_1), first advanced by the California station, was investigated by the Alabama station with results indicating that only when the major portion of the energy content of the diet comes from fat is there any significant decrease in the vitamin B requirement, thus suggesting that vitamin B may function in the relatively early stages of the carbohydrate metabolism in the body.

Studies of the effect of various vitamin deficiencies on carbohydrate metabolism have been extended by the Arkansas station to vitamins A, D, and G, but no abnormalities were found on any of the deficient diets except an increase in the apparent sugar (reducing nonsugar) content of the blood on vitamin A and D diets and a reduction in the glycogen content of the liver in vitamin G deficiency, the latter only in animals that had lost considerable weight during periods of inanition.

Basal metabolism studies.—An extensive investigation of the basal metabolism of women students at the Oklahoma Agricultural and Mechanical College was undertaken by the Oklahoma station primarily to determine the cause of marked underweight among these students. Preliminary studies on 58 students gave values averaging 10.6 per cent below the Aub-Du Bois standards, with the lowest value —27 per cent. Only six subjects had metabolic rates above these standards. An extension of the investigation to a total of 101 subjects, most of whom were from 18 to 25 and none over 36 years of age, and all either natives of the State or residents in the State for at least more than half their lives, gave average basal values in calories per square meter per hour 13.2 per cent below the Aub-Du Bois and 10.1 per cent below the Harris-Benedict and Dreyer standards. The individual values, however, for the most part fell within ±10 per cent of the averages of the respective age groups in which the subjects belonged, and a ±15 per cent range included all but one of the 101 subjects.

The Oklahoma station study also showed considerably higher values for the age group of 25 to 29 years. This was composed almost entirely of advanced nutrition students. An extension of the observations to the same number of students in the same age group but of varied and lower academic standing gave consistently lower results for the new group. Among the possible explanations suggested for the significantly higher values in the first group are that the group might have been a more select group physically or mentally, or that the figures represented a speeding up of general activities as the result of continued college life, or that the higher metabolism might be an expression of a degree of vitality acting as a factor affecting the choice of continued college careers. Whatever may be the explanation, the higher metabolism of this group is thought to emphasize the fallacy of basing standards intended for general application on observations of single homogeneous groups.

In observations of the basal metabolism of 38 overweight and 80 underweight students ranging in age from 17 to 28 years and in weight from —22 to +102 per cent of the normal according to the Wood standards, the Oklahoma station found that the overweight subjects tended to have a higher metabolism and the underweight a lower metabolism. The individual figures by calories per square meter per hour in 84 per cent of the cases, however, were within ±10 per cent and in 94 per cent of the cases within ±15 per cent of the averages obtained in the first study.

The growth of preschool children.—It has been the general impression, based upon periodic weight measurements, that growth is more or less seasonal in character, greater gains taking place in the summer and fall than in the spring and winter. The Kansas station attempted to overcome these seasonal differences by periodically exposing the children under observation to ultra-violet light during the winter months, or by supplementing their diet with orange juice. Neither measure had any effect upon gains in weight, which continued to be more rapid during the fall months than in January and February.

A much more extensive investigation of the rate of growth of preschool children was completed during the year by the Ohio station. The observations cover a period of three successive years, with a total of 173 records of height and weight gains, including 23 for a period of two years, 68 for one year, and 59 from 2 to 11 months. In weight gains the aver-

ages for the entire number of records were significantly larger for October and smaller for March and April than for any other months. Of the individual children, 85 made their greatest weight gains during the summer and 29 during the winter, and of the 23 children observed over a 2-year period 14 made greater gains in summer than in winter in both years and all but one during at least one of the years. These figures at first glance seem to prove quite conclusively that gains in weight of young children are seasonal in character. However, a further study of the group of 29 children who made greater gains in winter than in summer showed that 20 of these children had been in nursery school during the winter months, while in the summer their afternoon naps had been shortened or eliminated entirely. This indicates, as emphasized in the report of this investigation, that "any advantage which may possibly be inherent in one season over another may be overshadowed by environmental factors within the control of those who have the care of the child."

The gains in height of the children in the Ohio station study showed little seasonal influence or correlation with weight gains. February seemed to be the month of smallest gains in height for both boys and girls and November the month of greatest gain for the boys and August for the girls. The proportion of individual children making or exceeding the expected gains in height was larger than the proportion making or exceeding the expected gains in weight.

Information was secured on the diets of 114 of the Ohio children of whom 100 were members of families having at least an average income and 14 were members of families of a lower economic level. The diets of the larger group scored considerably higher than of the smaller group at the lower economic level. The principal differences in the diets were in milk, fruits, and cereals. Most of the children in the first group received a quart of milk a day and those in the second group only a pint. Orange and tomato juice were given to the children in the first group more regularly, perhaps because most of the children in this group attended nursery school. Cereals constituted a much higher proportion of the diet in the group of poorer children. The average yearly gains in height and weight of the children in the first group were 2.75 inches and 5.07 pounds and in the second group 2.57 inches and 3.53 pounds, respectively. Since even this group made the average expected gains in weight, the benefit of optimal versus adequate nutrition seems to have been demonstrated by the greater gains in the first group.

A more quantitative study of the food habits and physical development of preschool children over a 2-year period is being made by the Ohio station. Investigations of the food habits and food requirements of young children are in progress at the Michigan and Texas stations. Such studies as these have been made possible largely through the nursery-school movement, which has created a more intelligent interest among parents in the health and nutrition of their children and has made them willing to cooperate in these investigations.

SYBIL L. SMITH.

RURAL HOME MANAGEMENT

In spite of the increased purchasing power of the dollar, the rural home maker never needed greater wisdom in the management of her home than now, for in most cases there are fewer dollars to spend. The responsibility of feeding the family economically and adequately, of budgeting the family income satisfactorily, and of selecting intelligently such equipment as can be afforded rests largely upon her, and in addition she may feel it advisable and perhaps necessary to supplement the family income through outside activities of her own. In suggestions and advice along all these lines the experiment stations have made notable contributions during the year.

For example, the Missouri station found in a study of the diet of rural families that the food cost varied from 24 to 78 cents per man per day, but that the adequacy of the diet did not always run parallel to the cost, indicating that in many cases the cost might have been reduced by a wiser selection of foods without lowering the nutritive value of the diet.

The Mississippi station found that students in agricultural high schools of that State were being fed at a cost not exceeding 30 cents per person per day, but that the diet might have been improved by using more milk, fruit, and vegetables, which could have been produced on the school farms.

The average cost of food per man per day in rural homes in Vermont was found by the Vermont station to be 45 cents. A little over half of the cost was supplied by the farms which furnished over 90 per cent of the milk and dairy products, 81 per cent of the

potatoes and 78 per cent of the vegetables, a little less than 50 per cent of the meat, and, because Vermont is a maple sugar-producing State, 20 per cent of the sugar and sirup used per family. Changes which it was thought would improve the diet without increasing its cost were suggested by the station. (See also p. 84.)

In Ohio rural-home diets costing, during different years, $120, $121, and $134 per person per year, the Ohio station found that 55, 56, and 59 per cent, respectively, of the total food cost was represented by foods grown on the farms. The average cost per man per day of the adequate diets was 41 cents, but there was a wide range in the cost of such diets (34 to 50 cents), indicating that with slight changes in the food-purchasing plan adequate diets might have been secured at no greater average cost than that of the inadequate diets. A practical outcome of this study was a farm home makers' food budget providing for an adequate diet made up of the foods commonly used by the rural families. (See also p. 84.)

All of these studies emphasized the importance of greater farm production of foods for home use to increase the nutritive value and decrease the cost of the family diet.

The Nebraska, Rhode Island, and other stations have found that in many cases, especially during periods of depression, an important share of the family income comes from earnings of the home makers themselves. The effect of this earning capacity of the home maker is shown not only in its contribution to food and clothing but in improved household equipment and methods, in increased general efficiency of the household plant, and in aid to the hard-pressed farmer himself.

Such studies as these call attention to the adjustments which must be made in family living to meet the ever-growing outside occupational interests of rural women. Release of time is the first essential and this suggests the introduction of labor-saving equipment.

Study of the efficiency of household equipment by the Washington station has shown how electricity can be used economically and efficiently in cooking. For example, this station found that open units are in general faster and more efficient than closed units of the same wattage, and that special units of larger wattage, but of the same diameter, may be expected to be faster than the standard units but not more efficient. Other points of importance brought out by the study were that a high polish on oven utensils is not an advantage; price and performance are not necessarily related in such utensils—some of the cheaper utensils are more efficient than the more expensive and, with care, just as durable; waterless cooking can be done as well in a cheap pan as in an expensive one if it has a well-fitting cover; and the electric oven is most economical if used to capacity and not for one food alone. (See also p. 86.)

In tests of washing machines the Washington station found that a medium temperature of 125° F. gave best results and that prolonging washing was less effective in removing dirt than washing for a shorter period. In general it was shown that home laundering in this case was only a little less expensive than having the washing done in a power laundry.

FOOD CONSUMPTION AND EXPENDITURES

In times of prosperity the chief concern in food selection is the adequacy of the diet, with cost a minor consideration. In periods of economic depression, however, it becomes a matter of paramount importance to select food wisely from the standpoint of cost as well as of nutritional value. For this reason recently reported food consumption and expenditure studies, although covering a period of greater prosperity than the present, are of value in pointing out a rather wide range in selection and money value of the diets which measured up to the commonly accepted standards of adequacy.

Analysis by the Missouri station of estimates of the food consumption and expenditures of 70 farm families in a central community in Missouri during the year ended March 1, 1928, showed the diets to be conspicuously high in total calories, more than half totaling 5,000 calories or more per man per day, and also very high in protein, which averaged 13 per cent or more of the total calories. Approximately 40 per cent of the diets were classed as grade A, considered to have no deficiency but to be universally high in protein-rich foods; nearly 46 per cent grade B, frequently deficient in fruits and vegetables and occasionally in milk and often high in protein; and slightly over 14 per cent grade C, deficient in fruits, vegetables, and milk or very deficient in fruits and vegetables, high in protein, and either high or low in fat or sugar and occasionally in cereal.

The total expenditure for food varied from 24 to 78 cents per adult male unit per day, a wide range which did not, however, run parallel to the adequacy of the diets. One-fourth of the grade A diets and nearly half of the grade B were in the lowest cost range per 100-calorie portions and one of the grade C diets was in the highest cost range, indicating that the cost of many of the diets might have been lowered considerably by a wiser selection of foods without reducing the nutritive value of the diet.

As part of a general investigation of conditions in the agricultural high school dormitories in the State, the Mississippi station secured menus for three successive days from all dormitories, scored them for adequacy, and selected for an intensive, quantitative, food-consumption study certain schools in which the menus ranked high, average, and low in adequacy. The daily cost of the food was highest for the group considered from the preliminary survey to have the best menus, but there was very little difference between the other two groups. Inasmuch as the cost in no instance exceeded 30 cents per person per day, there were no cases of extravagant use of essential foods, but chiefly an excess of lower-priced energy foods and a deficiency in milk, fruits, and vegetables—a deficiency which might easily be remedied, as suggested in the report of this study, by greater production of these items on the school farm.

An analysis by the Vermont station of 50 detailed household records kept during 1928 to 1930 by women in different sections of the State showed that the average total food cost was $161 per man per year, or 45 cents per day. The average cost of the diets which seemed adequate in all respects was 52 cents per man per day and no diet costing under 40 cents met all of the requirements. A little over half of the total cost represented the value of foods supplied by the farm, which furnished on the average 95 per cent of the milk and dairy products, 81 per cent of the potatoes and 78 per cent of the other vegetables, a little less than 50 per cent of the meat, and, because Vermont is a maple sugar-producing State, 22 per cent of the sugar and sirup used by the family.

The average percentage distribution in money value among the food groups fell somewhat below customary accepted standards for milk and cereal products; above for meat, poultry, and fish, sugar and sirups, and vegetables and fruits; and corresponded closely with the standards for butter and other fats and for eggs. Adjustments in food selection by increasing the quantities of the items falling below the standard values (milk and cereals) and decreasing some of the items exceeding the standard might not necessarily increase food costs and would probably lower them in some cases.

A study recently completed by the Ohio station is of special value in that it covered three years, with 47 records for 1926, 68 for 1927, and 67 for 1928. For these years the money values of the diets averaged $134, $121, and $120 per man per year, respectively, and the percentages of these values represented by food grown on the farm 59, 56, and 55 per cent, respectively. The average expenditures for each of the principal food groups each year, calculated in percentages of the total cost, showed a remarkable constancy from year to year, with the exception of the two groups of protein-rich foods and of fruits and vegetables. These two groups together made up slightly more than half of the food budget and as the percentage cost of meat and other protein-rich foods increased that of fruits and vegetables decreased.

The Ohio study included 18 families who kept records for the three consecutive years. In this small group also the division of the food dollar among the food groups remained practically the same from year to year with the exception of the fruits and vegetables which dropped from 22 per cent of the total money value in 1926 to 18 per cent in 1928 and of meat and other protein-rich foods which increased from 30 per cent in 1926 to 33 per cent in 1928.

Although the diets of only 2 of the 18 families were adequate in all respects during each of the three years, those of 11 families were adequate or more than adequate in the averages for the entire period. The distribution of calories among each of the various food groups showed a wide range in both adequate and inadequate diets. Marked differences in the averages were shown only in the protein-high foods which were lower, and the fruits and vegetables which were higher in the adequate than in the inadequate diets.

The money values of the 11 adequate diets ranged from 34 to 50 cents, averaging 41 cents per man per day and of the inadequate from 22 to 51 cents, averaging 31 cents per man per day. The wide range in cost of the adequate diets and the fact that many diets in the group provided certain constituents far in excess of actual needs suggest that slight changes in

the spending plan would have made possible the selection of adequate diets at no greater average cost than that of the inadequate diets. A practical outcome of this study has been to assemble for the farm home makers' use a quantity food budget comprised of the actual amounts of the various foods used per man by each of the 11 families whose diets were adequate during the three years, together with the average nutritive value and cost of the diets.

As far as general recommendations can be made from the findings in such studies as these, the outstanding one seems to be increased production on the farm of foods for home use, such production being desirable from the standpoint of both increasing the nutritive value and decreasing the cost of the family diet. It is significant that in this 3-year study at the Ohio station the year during which the average value of the foods produced on the farm for use in the home was greatest in relation to total money values was also the year in which the nutritive value of the average diet was highest.

RURAL FAMILY LIVING

Food expenditures should not be considered alone, but in reference to all of the other items which make up family living. More or less fixed or absolute standards have been established for food requirements, but the standards for clothing, house furnishings, equipment, recreation, savings, and all of the varied items constituting family living are at best only relative and based upon the experiences and practices of large groups of people. Records of such practices among the rural groups of many States are now accumulating rapidly. Family-expenditure studies were reported during the year by the Illinois, Iowa, New York (Cornell), and Ohio stations. Each report is of special value to the rural people of the State in which the study was made. As stated in the report of the Illinois station, the information secured in such studies "may be suggestive to many women in indicating the need for more intelligent use of money and energy; and in bringing a better idea of the value of the food and shelter furnished by the farm, the total cash living expenditures of the family, and the desirability of making a more satisfying apportionment of the total, or 'realized,' income."

A comparison of the expenditures for food and clothing with reference to total expenditures as reported in these four studies showed a range in food expenditure of from 20.5 to 39.4 per cent and in clothing expenditure of from 8 to 20 per cent of the total expenditures. The averages for food and clothing together ranged from 35 to 51 per cent, with an average of 43.5 per cent of the total family expenditure. In more general terms, nearly half of the total family expenditures of these families are for the two essentials, food and clothing. How the rest of the income is spent can not be summarized briefly owing to the lack of uniformity in classification.

Many rural women, in addition to their home-making activities, are engaged in various farm tasks or outside enterprises. Attention is called in the 1930 report to an investigation in progress at the Rhode Island station on the frequency of paid work done by the rural women in one county of the State and some of the effects of this work upon family living. Since Rhode Island is a small industrial State, it is not surprising that approximately one-half of the wage-earning home makers in normal times work in the mills. The miscellaneous part-time occupations of the other half of these women have in many cases furnished the only cash income of the family for weeks and months at a time, during the business depression. The 288 women in the study who were able to give a fairly accurate statement of their earnings reported earnings totaling $4,655, or a per capita average of $16 a week.

The outcome of this Rhode Island study in so far as it concerns the effect of these outside occupations, so thoroughly justified from the viewpoint of their contribution to family finances, upon the home-making activities of these women has not yet been reported, but as pointed out in a recent journal article [8] on some of the preliminary findings, "manifestly, housekeeping and home-making duties can not be carried on in the same manner by these women as by their predecessors who had all their time in which to attend to their home duties."

According to a report from the Bureau of Home Economics in the 1928 Yearbook of the United States Department of Agriculture, the analysis of time records of 700 farm women (including the reports of various experiment station studies) showed that the

[8] WHITTEMORE, M. THE WAGE-EARNING HOMEMAKER AND THE FAMILY INCOME. Jour Home Econ., 23 (1931) : 1001.

average farm home maker spends a little over 11 hours each week on dairy work, poultry, and other farm tasks in addition to a little over 52 hours on regular home-making activities. Several of the experiment stations are attempting to determine to what extent this extra time, added to an already heavy schedule of working hours, is justified on the basis of its contribution to the family income.

Poultry and dairy products were the two enterprises selected by the Nebraska station in a study of this question by analyzing account books kept for a year, 1929–30, by over 150 women for each enterprise. The report of this study is naturally of greatest value to the individual women who kept the records. Some learned, perhaps for the first time, that in terms of net earnings they were actually losing money and others that the enterprise upon which they were engaged was even more profitable than they had thought. In terms of net income per hour for the time spent on the enterprise, 8 per cent of each group had lost money, while on the other hand 11 per cent of the poultry group and nearly 4 per cent of the dairy group had received a net income of $1 or more an hour. The average hourly incomes of the two groups, a little over 44 and 40 cents, respectively, were considered high enough to warrant the general conclusion that for the majority of the women taking part in the study the time spent in these activities was justified in the resulting contribution to the family income.

Such a study as this is quite as valuable in the questions it raises as in those it answers. The woman who was losing on the enterprise might well ask if it would be advisable for her to attempt to turn losses into profits by changes suggested by the practices of the more successful group, or if it might not be better to give up the enterprise. The woman with large cash returns on the other hand might ask herself and her husband if she would not be justified in availing herself of labor-saving devices and outside service agencies to release more of her time for the enterprise which was making such an important contribution to the family income. In making such a decision recent experiment station publications are of service in suggesting, as noted in the following section, the advantages and disadvantages of equipment of various types, the most economical ways of using equipment of rather high operating cost and the relative cost of carrying on certain household tasks in the home or making use of substitute services.

EFFICIENCY STUDIES OF THE HOUSEHOLD PLANT

Household equipment.—Household equipment, from small utensils for cooking to the relatively expensive electric range, refrigerator, or washing machine, should be selected so far as possible on the basis of performance.

In addition to the results of studies on the electric range and utensils noted on page 83, the Washington station found that in cooking several foods on surface units of an electric range (and presumably other ranges) economy can be effected by using triplicate saucepans over a single unit. If, however, only one food is to be cooked, it is poor economy to use a single pan of a triplicate set rather than a round pan. A great difference was found in the reaction to heat of utensils of the same size and shape, but different materials, to be used in an electric oven. Arranged in order of increasing speed and efficiency in the consumption of electricity the different utensils studied were aluminum pan, heavy stainless steel, light stainless steel, aluminum Dutch oven, aluminum pan coated with soot, enamel, glass, china, and cast iron. In selecting cooking utensils time and fuel can be saved by taking these differences into account. A high polish on oven utensils is undesirable and should not be striven for.

Other practical recommendations on selecting an electric oven and utensils and on the most economical use of the electric oven for vegetable cookery were published by the Washington station in a bulletin written particularly for the housewife. Among these recommendations, the following are particularly important from the standpoint of economy: "In the purchase of oven utensils remember that price and performance are not related. Some of the cheaper utensils are faster and more efficient than the more expensive ones and with care can be just as durable. * * * Waterless cooking can be done as well in a cheap pan as in an expensive one if it has a well-fitting cover. * * * If the electric oven is to be used economically it should be used to capacity, never for one food alone."

Electric washing machines can be selected and used more intelligently as a result of investigations reported by the Nebraska and Washington sta-

tions. In the Nebraska experiments machines of the gyrator, dolly, cylinder, and vacuum types were compared. The gyrator type was found to have slight advantages over the other types in the time required to wash uniformly soiled materials to maximum brightness or cleanliness and in causing less wear on the materials. The cylinder and vacuum types had advantages in the final brightness or cleanness of the material. Each machine appeared to have an optimum washing period that depended upon the character of the dirt and the temperature of the water. Medium temperatures, around 125° F., gave the best results. Washing clothing longer than the optimum period was found to redistribute the dirt over the fabric and washing at higher temperature to set the dirt in the meshes of the cloth. There also appeared to be an optimum load for each machine below or above which less satisfaction was obtained.

In this study considerable attention was given to the constructional features of the various types of machines which add convenience and safety. Some of the advantages and disadvantages found were listed. These lists might well serve as guides in selecting washing machines from the bewildering array of models on the market. They might also provide suggestions to manufacturers of such equipment on needed improvement in certain constructional features.

The efficiency of the home laundry plant was investigated at the Washington station. The report of this study describes the ideal home laundry plant of to-day in terms of the requirements for washing and ironing and discusses the cost of operation of such a plant in comparison with sending the family washing to a power laundry, with the conclusion that "when the cost of equipment, interest, depreciation, and materials are considered and when the housewife's time is figured at reasonable labor rates, the costs of doing the laundry at home are only a little less than the costs of sending the washing to the power laundry."

CONTRIBUTIONS TO THE PRESIDENT'S CONFERENCE ON HOME BUILDING AND HOME OWNERSHIP

Recognition of research in various phases of home management at the experiment stations was given by the planning committee of the President's Conference on Home Building and Home Ownership in the appointment of several experiment station research workers to the conference committees on farm and village housing; home making, housing, and family life; and kitchens and other work centers. The committee reports included special papers by representatives from the Arkansas station on the design of low-cost standard kitchen built-in storage units, from the Maryland station on farm houses and migration, from the Oregon station on requirements for work areas in the modern home, from the Washington station on the laundry studies referred to above, and from the Wisconsin station on the relation of housing to rural standards of living. The conference was of inestimable value to research workers in home management, through the assembling of existing information from many sources, and through the recommendations for future research included in the committee reports.

SYBIL L. SMITH.

AGRICULTURAL ENGINEERING

The overhead costs for mechanical and structural equipment and for improvement of lands on American farms are enormous, and the costs of labor and power expended in current agricultural operations constitute from 40 to 60 per cent of the total cost of agricultural production. The Washington station reports that the cost of labor, machinery, and power for wheat production by power methods is practically 45 per cent of the total cost of production. In addition, the Iowa and Ohio stations have estimated that the periods of useful service of much of the mechanical equipment used on farms are relatively short. With a view to reduction of such overhead and production costs, 41 of the stations have continued investigations which are yielding valuable results relating to more systematic and efficient mechanization of agricultural practices, provision of more efficiently designed and permanent farm structures, and reclamation and improvement of land.

Typical of the improvements in mechanical processes and equipment was the successful development of grain-combining methods and machinery along lines tending to reduce the high costs for labor and power and the relatively large losses of grain in harvesting. For example, the excessive labor requirement and grain losses and the danger of injury to animals in combining on hillsides were so reduced at some of the far northwestern stations by improvements in the bulk handling

of grain as to make combining practicable even under adverse conditions. With very little expenditure of money or labor for the necessary adjustments the wheat combine was successfully adapted by the Kansas station to harvesting and threshing suitable varieties of sorghums, overcoming in large measure the difficulty presented by the inability of some varieties to stand up under all weather conditions. The Michigan station made a similar adaptation of the combine for harvesting and threshing navy beans, overcoming to a considerable extent the tendency of the machinery to shatter the bean grains.

Weather injury to stacked grain and the excessive labor, time, and twine requirements of binder harvesting were reduced appreciably by the North Dakota station by combining the operations of a grain header and a mechanical stacker in harvesting. The straw, otherwise wasted, was all saved, and the quality of both the grain and the straw was improved. The windrowing process, as a preventive of the spoiling of combined grain which has ripened nonuniformly, was developed to a high degree of utility and economy at several widely separated stations, and the cutting and pick-up attachments of combines were generally improved so as to reduce the previous large losses of lodged grain and beans as much as two-thirds in many instances. These improvements represent typical advances toward reducing overhead costs for labor and power and produce corresponding reductions in the unit cost of crop production. Such reductions are vital to the success of the industry at this time.

Significant advances also were made toward increasing the durability and serviceability of farm buildings. These advances tended to reduce the high relative investment and maintenance costs and permitted more efficient and practical adaptation to types of farming. For example, the designs of framed large barns for livestock and general-purpose uses were improved by several stations where heavy windstorms occur frequently, so that the barns will better withstand such storms. Proper insulation and artificial heating of poultry houses, to maintain uniform temperatures and prevent sudden chilling of the poultry, were found by several of the stations, in localities with cold winter climates, to increase egg production appreciably during the winter when egg prices are high and production is normally low.

The trench silo was successfully substituted for the more expensive types of silo by several stations in the Middle West and South. It proved to be a cheap, useful, convenient, and easily constructed accessory to livestock and dairy farming in those localities. Power and labor costs of constructing and filling such silos were considerably lower than for the upright types. The previous large losses of soft corn, damp combined wheat, and other grains caused by heating in ordinary storages were prevented by several stations in the Middle and far West that developed specially ventilated storage bins of concrete, steel, or wood-frame construction, according to locality and type of grain stored. It was found possible by the Kansas station to safely store sorghums containing as much as 16 per cent moisture, in properly constructed and ventilated steel bins. The Indiana station was able to increase the quantity of apples remaining sound in storage by 4 per cent through the use of insulation and iced refrigeration in such storages.

These instances are typical of improvements in farm-building design and adaptation which have contributed directly toward reducing the unit cost of livestock, dairy, and poultry production, and to the economical maintenance of superior quality in crop, fruit, and vegetable products while stored awaiting favorable marketing periods.

Much was accomplished by several stations in the Middle West and Central South toward preventing soil-fertility impairment by erosion and storm run-off, which is recognized as one of American agriculture's most important economic problems in land improvement. For example, soil and water losses through erosion and run-off were practically prevented in northwest Texas and similar localities by the use of systems of contoured rows and closed level terraces devised by the Texas station and the United States Department of Agriculture. Other stations in the Middle West and Central South, in cooperation with the department, successfully established the grades for terraces which will prevent erosion of some of the important soil types of those localities under different kinds of crop cover.

Important savings in the cost of labor and power also resulted from further adaptation of electricity to agriculture. The Idaho station showed that mechanical milking, using elec-

trical energy, reduced labor in dairy production by nearly five man-hours per 1,000 pounds of milk produced. The electrical brooding of young chicks was accomplished by several middle western and far western stations with considerably greater economy and efficiency than where ordinary forms of heat energy were used. The labor requirement for care, as well as chick mortality, was reduced appreciably and the fire hazard was practically eliminated. The electrical heating of incubators was developed to a similar practical basis.

These and numerous other practical improvements in the mechanics of farm production accomplished during the year at the stations are reviewed in greater detail hereafter.

MECHANICAL EQUIPMENT

Labor and power costs American agriculture approximately $4,000,000,000 a year. Efforts of the stations to reduce this cost in current crop-production practices have achieved considerable success.

Harvesting machinery.—Efforts to improve combines and combining practices, with the object of securing a greater return, in terms of quantity and quality of grain crops, from the investment of labor, power, and machinery in harvesting, were continued by the South Dakota, Michigan, Pennsylvania, Washington, Ohio, North Dakota, Iowa, Kansas, Indiana, Alabama, Illinois, California, and Idaho stations.

Progress in increasing the separating efficiency of prairie-type combines on cross grades was reported by the Pennsylvania and Iowa stations. The Pennsylvania station accomplished this by decreasing the amount of straw handled. The utility and economy of the windrowing process were increased and grain losses reduced by the South Dakota station by using heavy windrows and decreasing the speed of picking up from 3 to 2 miles per hour. It was possible by this means to thresh a swath of oats from 4 to 6 feet wider than the cutting width of the combine. The Ohio station not only reduced grain losses by cutting the stubble as high as 11 or 12 inches, but improved the windrow support and made the pick-up operation more efficient. The Alabama station found that the windrow harvester, when used with the pick-up attachment on the combine, was better adapted to harvesting oats under Alabama conditions than the combine alone, and the Michigan station, by use of the windrower, was able to obviate trouble in drying caused by excessive moisture in the grain.

Low-cutting attachments for combines, leaving only a 2-inch stubble, were found by the Indiana station to reduce the cutter-bar losses to a minimum, and the labor required for harvesting with the combine was reduced by proper adjustment and operation to approximately one-fourth of that required by the binder and thresher method.

The windrow pick-up method was successfully adapted to harvesting rice by the California station as far as the mechanical requirements were concerned, but it was found that the condition of the straw rather than the moisture in the grain is the limiting factor in handling rice with the combine.

Handling grain in bulk from hillside-type combines was found by the Idaho station to lower labor expense and grain losses. It was also shown that the direct-haul method is adapted to short hauls and level fields, and that the use of an intermediate field bin will permit the bulk handling of grain from very steep hillsides where the hauls are long.

The wheat combine was successfully adapted by the Kansas station to harvesting and threshing certain suitable varieties of sorghums, although it was found that many varieties can not be combined successfully, because of their inability to stand up in all kinds of weather. It is necessary to take considerable stalk and leaves in order to get all of the heads in threshing, but the methods and equipment were developed to the point of showing that two men can harvest as much as 200 bushels per hour at a cost of about 62 cents per acre.

Under favorable weather conditions, the combine, when properly equipped with a regular bean cylinder, concaves having proper speed reductions, and sieves, will satisfactorily harvest and thresh navy beans, either as a stationary outfit in the field or in motion, using a windrow pick-up according to the Michigan station. The lines along which both the combine and bean thresher can be improved for this purpose, with particular reference to the prevention of bean cracking, were determined.

By combining a grain header and mechanical stacker, the North Dakota station was able to produce a finished stack which was weather resistant and

protected the grain from excessive shrinkage. The quality of both grain and the straw was improved by the process, and the stacks were more easily hauled to the thresher on sweep rakes than was bundle grain on racks. The process saves all the straw and has been found to save labor, time, and twine, and to permit earlier plowing.

In efforts to improve corn-harvesting methods and equipment, the South Dakota station demonstrated that the optimum diameter of husking roll for stationary mechanical huskers is between 3.5 and 4 inches, the optimum length of roll is from 36 to 42 inches, the most satisfactory husking peg is a flat-headed stud, and the optimum speed of rolls is 300 revolutions per minute. The Iowa and Illinois stations reported progress toward greater standardization of the mechanical corn-picking method and the corresponding machinery, with the object of securing simplicity as well as economy in both. The harvesting of corn with the combine was developed beyond the experimental stage by the Kansas station, it being found that the combination corn and wheat machine is a dual-purpose combine which can be used more days during the year, thereby reducing the overhead cost of purchasing and maintaining the equipment necessary for harvesting large and small grains.

The binder method of cutting fodder in the field has been developed by the Missouri station to a point where it is cheaper than the hand method for acreages of from 30 to 35 and cheaper than the sled method for acreages above 50.

Harvesting cornstalks for industrial uses reached the practical stage at the Iowa station during the year. Harvesting by breaking, raking, and baling in the field was found to be very practicable, costing about $3.55 per ton under average conditions. Combination machines consisting of mower, rake, and baler were found to reduce labor, and a reasonable estimate of the overhead cost of machinery is 50 cents per ton.

Cotton snapping was successfully adapted by the Alabama station to certain conditions in the State with savings of over half of the time required for hand picking, and from $2 to $4 per bale of cotton after a slight loss for grade was deducted. The Texas station also made progress in developing labor-saving mechanical methods and equipment for harvesting cotton, and showed that this problem may be attacked profitably from the standpoints of both cotton plant breeding and machinery development.

Tillage machinery.—Studies of the fundamental principles of soil dynamics governing the design of tillage tools were continued by the Alabama, Kansas, and Nebraska stations. The Alabama station established definite relations between the colloid and moisture contents of soil and the power requirements of tillage as affected by frictional resistance between soil and metal surfaces and resistance to tillage due to soil cohesion. The Kansas station found that friction between soil and metal surfaces decreased with coarse granulation and increased with fine granulation of soil but was independent of pressure and area of contact between metal and soil and of speed of movement of soil over metal. The Alabama station also found in practical tests of these findings that the cylinder-disk plow was profitably adapted for plowing sandy or sandy loam soil, and that the weed infestation on sandy loam soil was reduced from 75 to 78 per cent by the use of an adjustable spike-tooth harrow without seriously injuring the stand of cotton. The rotary hoe was satisfactorily adapted for the cultivation of young corn and cotton during a dry season on both black belt and sandy soils, and hand hoeing was completely eliminated and the labor cost of thinning materially reduced by checkrow planting. The Michigan station was successful in increasing the wearing properties of plowshares by the use of steel alloys in their treatment, thereby reducing their maintenance cost per acre plowed.

Traction machinery.—The Pennsylvania station continued to develop combination cushion-spring and clutch-release hitches to prevent breakage and high maintenance costs for tractors operating tillage implements in rough and stony soils. The Montana station reported on the arrangement and methods of using tractor-drawn equipment under local conditions to permit greater economy and efficiency in tractor farming.

Studies of air cleaners for tractor engines, which were completed by the California station during the year, have given much technical and practical information on the design, installation, operation, and care of such cleaners. The California station has also improved the process and equipment for filtering tractor engine oil, thereby appreciably reducing bearing wear and the cost of tractor maintenance.

As a result of studies on the factors influencing the tractive efficiency of

wheel-driven tractors, the Alabama station showed the possibility of designing tractor drivewheels and lugs which will transmit a maximum of tractive power even in soils having low tractive properties. The principles derived from this study have made it possible in farm operations to save considerable draft power which would otherwise be lost through drivewheel slip.

Studies of the development and adaptation of the general-purpose tractor along cost-saving lines were continued by the Virginia, Pennsylvania, Iowa, Ohio, Alabama, and Louisiana stations. The Pennsylvania station has succeeded in adapting the general-purpose tractor to corn production with increased economy in time and labor. The Virginia station has been able to secure greater stability of the general-purpose tractor for farming hilly lands, and has made some of the findings of practical use to farmers on such lands.

Animals are still important draft-power units on farms. The Minnesota station, for example, has pointed out that horses are the most important source of power on the farms of the State from the standpoint of horse-power hours actually utilized. The Illinois station is one of several that have established the fact that pulling power of horses is closely associated with large size, great heart girth, and calm disposition.

Feed-processing machinery.—Several stations have reported investigations in the development of economical methods and machinery for processing feeds and forage. The Kansas and Missouri stations succeeded in materially reducing the labor and power expense of silage cutting and elevating, the former station demonstrating that cutter speeds should be maintained at from 400 to 550 revolutions per minute when elevating silage to heights around 40 feet.

In developing grain grinders, the Ohio station succeeded in bringing the straight-hammer type feed mill to a high point of efficiency in grinding barley, oats, corn stover, and soybean hay, and demonstrating the superior utility of burr mills for corn grinding. The Kansas station found it profitable, under most conditions, to grind small grains for livestock, and demonstrated the wider utility of the combination hammer and plate type of mill over other types. It was found possible, by the Pennsylvania station, to produce a ton of any required ration in less than four hours with a relatively low power consumption by using a continuous feed-grinding and mixing plant, thus materially reducing the cost.

Planting and fertilizer machinery.—The Ohio station made progress in developing a safe and efficient combination corn planter and fertilizer attachment which places the fertilizer in two lateral bands 3 inches apart, one on either side of and approximately 0.5 inch above the seed, thereby increasing the utility of the machine, improving the planting and fertilizing operations, and increasing the unit efficiency of the labor and power used.

Fluted and internal double-feed types of force-feed grain drills were successfully adapted by the North Dakota station to planting a uniform quantity of seed corn per acre, although the spacing was not entirely satisfactory. Beet drills were found to plant as efficiently as corn planters when equipped with special corn plates. The Mississippi, Alabama, and Texas stations reported progress in developing methods and machinery for planting cotton in soils which form crusts after rainfall, the Alabama and Texas stations especially being successful in measuring the rupturing strength of the soil crusts and in determining the corresponding planting requirements.

Dairy machinery.—Studies on the use of solar heat for heating water for dairies were completed by the Alabama station, and a practical and efficient design of solar heater for this purpose was developed, making it possible, under favorable conditions, to reduce the cost of dairy-production operations.

As a result of studies of methods and equipment for milk cooling, the Nebraska station reported technical and practical information on the construction of mechanical dairy coolers and cold rooms. The New York State station determined some of the essential facts about proper milk-cooling equipment, among them, that the cooling tank should be large enough to provide twice as much ice and water as milk and should be insulated with 3 inches of cork or its equivalent, and that milk can be cooled satisfactorily by placing it immediately in water at 40° F., provided the tank is of ample size and well insulated and a large enough source of refrigeration is available.

Studies of water-vapor sterilizers for dairy equipment by the Oregon station indicated that 175° F. is the minimum sterilizing temperature. The California station succeeded in heating dairy-equipment sterilizers more eco-

nomically with compressed natural gas than with kerosene.

Orchard-spraying machinery.—The West Virginia station, after a thorough study, reports that stationary spraying plants have been adapted to every type of topography in the State, and are now in use in orchards where portable sprayers could be used only with the greatest difficulty and expense. The station found that the initial cost of the stationary system for orchards of commercial size need be no greater than that of corresponding portable equipment. Progress along similar lines also was reported by the Indiana, Illinois, and Washington stations.

Sprayer accessories materially affect the efficiency of orchard and truck spraying equipment, according to the Michigan station, which reported progress in developing more efficient accessories, such as hose, hose fittings, cut-offs, rod parts, and gun and nozzle disks. Practical information on the proper design and regulation of spray-agitating equipment in order to maintain uniform mixtures of spray material with a minimum power requirement was secured by the California station. It was found, for example, that the power consumption is greatest for any given speed when the agitating blades are set in a common plane and are completely submerged.

Corn-drying equipment.—Efforts to develop economical methods and efficient equipment for maintaining the quality of hay and grain crops by artificial curing, regardless of the conditions of harvesting, were continued at the Louisiana, Mississippi, Kansas, Wisconsin, Illinois, Pennsylvania, Indiana, and North Dakota stations.

As a result of work on grain drying, the Pennsylvania station reported progress in developing portable drying equipment for grain combines, and the Illinois station in developing practical air-conditioning equipment for curing soft corn under temperature and humidity conditions resulting in the least injury to the germinating and other properties of the corn. The Indiana station, at a cost for fuel and labor of only 3 cents per bushel, reduced the moisture content of river-bottom corn from about 65 per cent in the cob and 35 per cent in the grain to 30 per cent in the cob and 18 per cent in the grain by forcing heated air up through an air-distributing tunnel extending through the middle of the crib for its full length. The Michigan station demonstrated the utility of a unit drier for seed corn consisting of a shallow, bottomless, electrically heated box with insulated sides and top.

As a result of a study of principles governing the passage of air through rice in deep bins, the California station was able to design efficient air-drying equipment for this grain.

In efforts to develop methods and equipment for drying hay and other forage, the Louisiana station succeeded in improving and cheapening the operation of the single-drum rotary type of drier designed for use in very humid climates, and the Illinois station in drying round haystacks with heated air from an oil furnace. The Indiana station used heated air for this purpose, with the hay on false bottoms in large sheet-iron tanks, and by this means hay cut and blown into the tanks with a silage cutter was dried satisfactorily at the rate of 400 pounds of dry hay per hour. The same equipment also was adapted to drying wheat which had passed through the hot-water treatment for smut.

STRUCTURES

Structures on American farms now represent an investment approximating $12,000,000,000 and their maintenance costs nearly $7,000,000 a year. The Missouri station found that probably the greatest loss on farm buildings on certain typical farms in the State is due to lack of use, because the buildings do not fit adequately into the schemes of farming pursued.

Considerable progress was reported in developing plans for more permanent, durable, and efficient dwellings, crop storages, and animal shelters which are better adapted to the types of farming they serve.

Poultry structures.—Hens can thrive in an environment where there is very little air change, according to the Nebraska and Indiana stations, and so long as the temperature changes are small no great benefit results from the use of special ventilating devices in poultry houses. However, the insulation of poultry houses to prevent sudden extreme temperature changes has a beneficial effect on winter egg production in cold climates.

Artificial heating of poultry houses increases winter egg production, according to the Nebraska and Michigan stations, and the latter station successfully converted brooder stoves into poultry-house heaters. However, the New York (Cornell) station secured better and cheaper production by using the open-front poultry house.

The practical utility and sanitary character of concrete floors laid on the ground, and of solid partitions in poultry houses, were demonstrated by the Washington station.

The utility and cheapness of the shed-roof poultry house were demonstrated by the Illinois station. Rammed earth, if kept dry, was used satisfactorily by the California station in the construction of poultry houses, and it was found that finish coats of stucco and mud plaster weather more satisfactorily than painted surfaces.

Plans and specifications for poultry houses found useful and efficient under the conditions in the State were published by the Missouri station. Results of studies of the practical aspects of poultry-house construction and equipment were reported by the Montana station in a form available for the use of poultry raisers. The New Jersey stations prepared and published plans for the construction of the multiple-unit laying house perfected during the year.

Dairy structures.—In a study of dairy-barn construction and ventilation, the Iowa station showed that fans with automatic control are a promising development in dairy-barn ventilation, and make it possible to control ventilation much more positively than where air circulation is induced solely by rarefaction due to heating. The superior durability of concrete and rubber over other types of materials for dairy-barn floors, and the value of asphalt paint having a melting point sufficiently high to resist the heat of the sun, for waterproofing the tile roofs of masonry-arch dairy barns, were demonstrated by the same station. By the use of asphalt paint it was possible to reduce the cost of material for roof treatment to a very reasonable figure.

The trench silo as a cheap, useful, and practical structure was improved by the Alabama, Colorado, Nebraska, and North Dakota stations during the year. These stations have found the trench silo to be considerably more economical of power and labor in construction and filling than is the upright silo. The Illinois station reported progress in developing satisfactory milk houses and published working drawings and practical information for their construction.

Crop storages.—The use of insulation and ice in apple storages partially below ground was found by the Indiana station to reduce the temperature from 5° to 14° below that in air-cooled storages, to maintain the temperature below 50° F., and to result in 4 per cent more sound fruit. The Michigan station reported on ventilating potato warehouses by forced draft, and the New Hampshire station on remodeling farmhouse cellars for the storage of potatoes, with particular reference to the proper installation of insulating material.

Storages for damp combined wheat, which obviate losses by heating, were developed to the practical stage by the Kansas station, and the effectiveness of the blower elevator in cooling heated wheat was demonstrated. It was found that damp wheat can be stored without injury in concrete-stave bins placed on a concrete foundation and floor with the outside surface waterproofed, and in wooden bins with lumber coverings both inside and outside of 6-inch studs. Circular steel bins set on wooden floors with ventilated side walls and central ventilating flue also gave good results. Sorghums containing 16 per cent moisture were safely stored in well-ventilated steel bins. The California station developed the design of sheet-metal and concrete-stave grain-storage structures to a practical point with reference to safety as well as economy in construction, and also reported progress in improving storage facilities for rice.

Construction materials.—Efforts to develop cheaper and more durable construction materials were continued by a number of stations. The South Dakota station found that considerable sand is necessary in soils used in rammed-earth buildings in order to absorb the shrinkage stresses, and the California station improved the walls of rammed-earth buildings by mixing lime with the earth.

The value of pressure-treated pine and galvanized-steel fence posts was demonstrated by the Arkansas station.

Dense concrete tile show considerable durability in peat soils, according to the Wisconsin station, but when laid in mineral soils they actually improve with age and are approximately 26 per cent stronger than when laid in peat soils.

LAND DEVELOPMENT

During the year a number of stations reported on methods for the economical improvement of the more productive lands by irrigation, drainage, and the removal of stones, stumps, and brush.

Irrigation.—Additional information on the control and conservation of mountain snow-water resources for irrigation use was secured by the Utah sta-

tion, on the adaptation of large Venturi flumes to the measurement and control of irrigation water in main canals by the Colorado station, and on practical aspects of flood irrigation by the Montana station.

In studying the economy and effectiveness of rice irrigation, the Louisiana station found that when using pumped water operating-labor costs tend to decrease as the area flooded is increased. The Arkansas station showed that a crop of rice can be adequately irrigated with a total depth of from 27 to 30 inches of water, including rainfall, during a season, and with a rate of flow of irrigation water of 1 cubic foot per second for each 80 acres irrigated. The total cost of pumping varied from $10 to $12 per acre for lifts of 100 feet. For fields of 150 acres or less, electricity was usually the more economical source of power, while for fields larger than 160 acres oil engines were more economical.

Sprinklers were found by the Washington station to be more economical than the rill system in applying irrigation water to orchards on sloping sandy soils with light subsoils. The Oregon station showed how standard crops can be produced under irrigation in the Harney Valley at a satisfactory profit with water pumped from wells within the probable pumping lift in the valley. The same station also secured useful information on the irrigation of dairy pastures, vegetables, and small fruits as well as field crops in the Willamette Valley of western Oregon, indicating that irrigation of these crops is approaching standard practice in the valley. The pasture-irrigation experiments showed, for example, that a stream of at least 1 cubic foot per second should be available to prevent loss of time or water.

Drainage.—The New Mexico station reported further studies on drainage-water movement in alkali soils and on the drainage of the soils of the middle Rio Grande Valley as influenced by ground-water level. The Oregon station reported on the proper design of drainage wells, on methods of underground drainage of orchards under the high water-table conditions encountered in the Medford area, and on wet-land reclamation with particular reference to the soils of western Oregon.

The efficiency of concentrated loading in the use of dynamite for the maintenance of open drainage ditches was demonstrated by the Ohio station. Dynamite also was found to be a quick and easy means of ditch maintenance which can often be used economically where the ditches are too small to warrant the use of dredging equipment.

Erosion and run-off control.—Several stations reported results of experiments in preventing soil erosion and controlling storm water run-off during the year. The Texas station found that it is possible to practically prevent run-off in northwest Texas by the use of contoured rows and closed level terraces, and that grass is the most effective cover for conserving run-off. The Texas station also found that the efficiency of terracing machinery is directly proportional to the ability of the blades to penetrate the soil and to their scouring qualities.

The optimum grades for terrace flow lines in local soils and for different types of crop cover were successfully established by the Indiana station. The Oklahoma station showed that terrace ridges can be constructed more cheaply with the crawler type of tractor and grader than with the wheel type, and secured additional information of practical use to farmers on the proper vertical interval between terrace ridges for minimum run-off from certain soil types.

The effect of forest cover on the control of erosion and run-off was determined by the California and Wisconsin stations. The Wisconsin station has found that the most immediate and direct cause of destructive erosion is the disturbance of the natural balance between gravitation and the binding power of roots in soil and the force of running water.

RURAL ELECTRIFICATION

To meet the increasing demand for information on the economical and efficient adaptation of electricity to agricultural uses, the stations enlarged and strengthened their programs of research in rural electrification during the year, with results which promise to be of much practical value.

Feed processing.—The Idaho, Indiana, Kansas, Nebraska, Oregon, Pennsylvania, and Texas stations developed the efficient use of electric motors for operating feed grinders, silage cutters and blowers, and hay choppers. The Nebraska station demonstrated the utility of the 3-horsepower motor for feed grinding and silage cutting, and the Indiana station improved the mechanism of silage cutters and husker shredders to permit the practical and

economical use of 5-horsepower motors in their operation. The Indiana station also successfully adapted the 10-horsepower motor to threshing wheat, oats, and soybeans, with a saving of time and labor. The Kansas station found the electric motor an ideal power unit for grain grinding, the cost of its power being about the same as that of gasoline-engine power. A grinder speed of from 500 to 600 revolutions per minute was found to be the most economical of power.

Dairy production.—Progress in developing efficiency in cooling milk by electricity was reported by the California, Indiana, Oregon, Pennsylvania, and Washington stations.

The cost of electric ventilating equipment for dairy barns, including installation, may, according to the Michigan station, be made considerably less than the annual cost of the equipment necessary in natural airflow systems of ventilation.

Mechanical milking, using electrical energy, was developed along labor-saving lines by the Idaho station, which found that the saving of time in manhours effected by this machine and other electrically operated equipment amounted to 4 hours and 42 minutes per 1,000 pounds of milk produced.

Poultry production.—In studies of electric brooding of young chicks, the Indiana station found that by proper adjustment and control the cost of electricity at 3 cents per kilowatt-hour for this purpose could be made considerably less than the cost of hard coal at $16 per ton. The Michigan station successfully adapted electricity to heating incubators designed to operate on kerosene, thereby reducing the fire risk and the labor required for care. The Michigan station also demonstrated that heat may be advantageously applied in the floors of poultry houses by electricity, thus keeping the litter dry as well as modifying the room temperature so that egg production is maintained through periods of severe cold.

Hotbeds.—Investigations of electric hotbeds were continued by the California, Missouri, New York (Cornell), Texas, and Washington stations. The Missouri station was able to substitute electricity for manure in hotbeds and demonstrated the superior economy of immersion heater cables over oven-type heaters for this purpose. The New York (Cornell) station developed electrically heated hotbeds, using glass sash, to the point at which fairly high temperatures can be maintained economically in very cold weather, and remarkably uniform soil and air temperatures can be maintained in spite of rather extreme changes in outdoor temperature.

Miscellaneous uses of electricity.—Progress also was reported by the stations in adapting electricity to other agricultural purposes, notably drainage and irrigation pumping, sprinkler irrigation of orchards, sawing wood, and elevating grain, by the Washington station; heating water for stock and poultry by the Idaho station; and orchard insect pest control by electrical illumination, by the New Jersey stations. The Kansas station materially extended the practical and economical adaptation of small electric motors to different farm uses, especially in the farm home, and the New York (Cornell) station brought its investigations of the best farm electric-wiring practices to a practical conclusion. The California station reported the development of a satisfactory non-walk-in type of general-utility farm refrigerator.

ROBERT W. TRULLINGER.

AGRICULTURAL ECONOMICS

The unfavorable conditions existing in agriculture have given rise to heavy demands on the experiment stations for information and investigations in the entire field of agricultural economics. In consequence, the stations have covered a wide range of investigations in taxation, farm credit, farm management, costs of production, prices, purchasing power of agricultural products, cooperation, and other lines. Notwithstanding the fact that many of the demands were for information to assist in solving immediately pressing problems, methods of investigation showed substantial improvement, personnel was strengthened, and projects, through revisions, were set up on a stronger research basis not only from a local, but also from regional and national viewpoints.

Some of the results of the work during the past year are briefly noted below and in somewhat more detail later.

The percentages of net cash and labor incomes of farmers taken by taxes are greatly in excess of those taken before the World War and in excess of the ability of agriculture to pay. The Connecticut (Storrs) station found that agricultural taxes increased 130 per cent from 1915 to 1928, while farm prices of agricultural products increased only 51 per cent. (See also p. 97.) A study by the Ohio station

showed that in terms of cash income farm taxes increased 60 per cent from 1913 to 1928, and that in the latter year approximately 38.4 per cent of the net rent on cash-rented farms was absorbed by taxes as compared with 17.1 per cent in 1900. Taxes in 1924 and 1925 in Pennsylvania were found by the Pennsylvania station to have taken 38 per cent of the net income of agriculture and of mining corporations as compared with 13 to 27 per cent for other groups of enterprises.

Inequality in assessment of lands for taxation is a cause of much of the heavy tax burden of individual farmers. Assessed valuations of farms studied by the Connecticut (Storrs) station varied from 20 per cent to over 100 per cent of the estimated values. Farms studied by the Ohio station showed assessed valuations ranging from less than 20 per cent to over 175 per cent of the sale prices. In studies by the Pennsylvania and Texas stations, it was found that assessed valuations ranged from about 10 per cent to over 150 per cent and from 15 to 118 per cent, respectively, of the sale prices.

Annual operating expenses of schools were found by the Michigan station to increase steadily from $900 for those with 3 pupils to $1,600 for those with 45 pupils. In Laramie County, Colo., the Colorado station found the annual cost per pupil ranged from $61 to $416 in different school districts. The average was $147 in country districts and $120 in town and city districts, notwithstanding that teachers' salaries in the latter averaged $604 a year higher and teachers averaged 6.7 years more experience. School-tax levies per $1,000 valuation ranged from 12 cents to over $63 in the school districts of Michigan and from $57.50 to approximately $256 in those of Colorado.

Granting patrons credit on side-line purchases is costing Iowa farmers' elevators an average of $1,943 each per year, according to a study of the Iowa station. About two-thirds of this cost, it was found, is being shifted to cash and grain patrons.

The cost of producing apples, the Michigan station found, has increased 150 to 225 per cent, and that of peaches 180 to 230 per cent, since the period 1850–1875, while the present purchasing power of apples is only 125 to 175 per cent of the former period and that of peaches only 25 to 50 per cent.

A decline in the number of horses and mules, a decrease in the purchasing power of hogs and cattle, changes in production practices for corn and livestock, and extension of the Corn Belt were found by the Iowa station to account in large measure for the 25 per cent decrease in the purchasing power of corn since the World War. The study indicated a further slow decline.

Studies by several stations in the cotton States showed that only about 20 to 33 per cent of the central-market premiums and discounts for grade and staple length of cotton are passed along to the growers in local-market prices. In general, it was found that the local markets discounted the poorer grades and shorter staples less and paid smaller premiums for the better grades and longer staples than did the central markets, there being a tendency for local buyers to class all cotton in a few of the middle classes as to grade and staple length. Some recognition of quality on a community basis was found, but even in such cases the superior quality of the cotton was not fully reflected in the prices paid.

The most efficient size of range beef cattle enterprise was found by the Montana station to be from 300 to 800 head. Operating expenses tended to decrease as size increased up to 500 or 600 head, and gross income per head increased up to 400 head and then decreased.

On commercial egg farms, the Oregon station found that an average of 110 eggs per hen per year was necessary in order to pay bare cash expenses, and 170 eggs to pay all costs. The minimum economic poultry unit for diversified farms was found to be 400 hens, with 600 a better size and for 1-operator, full-time poultry farms the minimum unit is from 1,200 to 1,500 hens.

Studies of cooperative livestock associations made by the Illinois station and studies of purchasing associations made by the Pennsylvania station showed that the greater part of the members believed the associations aided them financially. Only about one-third of the members of the Illinois associations, however, had given any thought to their individual responsibility to the association. In the Pennsylvania associations, less than 60 per cent of the members had talked to their neighbors about the association, and only 58 per cent purchased commodities handled by the associations to the extent of 75 per cent of their needs. (See also p. 105.)

The automobile, good roads, and shorter hours in industries have awakened an increased interest in part-time farming, especially among employees

in industrial plants in towns and small cities. The Massachusetts station found that at least a third of the agricultural production of the State is from such enterprises. This type of farming is largely on submarginal land and is increasing tax receipts in decadent farm areas and insuring better living conditions and economic stability of wage earners.

TAXATION

The disproportionate and increasing burden of taxation borne by farmers as compared with other classes of people and industries, on the basis of prices received for products, net income, labor income, and benefits received, was emphasized in practically all the investigations reported on by 10 stations during the year.

In a study of agricultural taxes, the Connecticut (Storrs) station found that property taxes took 9.5 per cent of the net income and 29.5 per cent of the labor income in 1926 on 187 tobacco farms, and 13.8 and 18 per cent, respectively, on 117 dairy farms in 1928, and 9.4 and 11.7 per cent, respectively, on 71 dairy farms in 1929. On 358 farms studied by the Arkansas station, taxes in 1928 were 9.9 per cent of the expenses and took 11.1 per cent of the net returns. In 1929 taxes absorbed 7.4 per cent of the net returns on 542 farms studied, being the lowest percentage for any year of the period studied, 1923–1929.

Farm taxes in Ohio in terms of cash income were found by the Ohio station to be 60 per cent higher in 1928 than in 1913. Property taxes and assessments, 1921–1928, took 12.6 per cent of the gross cash, 20.6 per cent of the net cash, and 12.6 per cent of the net agricultural income, and in addition about 2 per cent of the total net income of farmers went for other taxes. Of the net rent of cash-rented farms studied, approximately 38.4 per cent went for taxes in 1928 as compared with 17.1 per cent in 1900.

Taxes per acre on rural lands in Choctaw County, Miss., were 7.44 cents in 1917 and 30.44 cents in 1928, according to a study of the Mississippi station. In Collin County, Tex., the percentage that taxes were of farm income per acre on rented farms was found by the Texas station to have increased from 11.8 in 1924 to 24.5 in 1926, and then decreased to 18.7 in 1929. Colorado farmers in 1928 received less than 20 per cent of the total income of the State, yet paid 35 per cent of the total property taxes, according to a study by the Colorado station. General property taxes in New York were found by the New York (Cornell) station to have increased from $18.39 per $1,000 full valuation in 1915 to $22.31 in 1928, while the rates on other sources of taxes had been moderate and, in most cases, had not increased.

Inequality of assessment of farm lands in the same taxing unit was found to be the cause of much of the undue tax burden on such lands. The assessments on 283 farms, studied by the Connecticut (Storrs) station, varied from 20 per cent to over 100 per cent of the estimated value, 42 being assessed at less than 40 per cent and 68 at over 80 per cent. High-value farms were decidedly underassessed, in relation to low-value farms. The assessed valuations for 1,599 farms, studied by the Ohio station, ranged from less than 20 per cent to over 175 per cent of the sale price, one-half being from 69 to 102 per cent. In the Pennsylvania station investigation, the variation was from about 10 per cent to over 150 per cent of selling prices. The assessment rates were usually lower in cities than in townships. In a Mississippi station study, assessed values ranged from 38.9 per cent of the estimated value for 61-acre to 140-acre farms, to 72.8 per cent for 221-acre to 300-acre farms. Assessed valuations were found, in the Texas station study in Collin County, to have dropped from 32.9 per cent of sale prices in 1915 to 16.2 per cent in 1919, then increased to 38.9 per cent and 34.2 per cent, respectively, in 1928 and 1929. The range on 177 farms in 1929 was from 15 per cent to 118 per cent, averaging 34.2 per cent.

Special studies of the costs and methods of financing schools were made by the Michigan and Colorado stations. Local school taxes in Michigan formed nearly one-third of the general property tax, which constituted approximately 75 per cent of the income of the State. In 1927 school-tax rates varied from 12 cents to $63.52 per $1,000 valuation in different districts. In 49 of the 66 counties of the lower peninsula, the districts having the highest total assessed valuation received as much or more State aid than the districts with the lowest total valuation. The number of pupils per teacher in districts having elementary schools with more than one room, but no high school, averaged about 28; in high schools having an average

daily attendance of fewer than 50 pupils, 13; and in high schools with an average daily attendance of approximately 400 or over, 20. In the 1-room schools, numbering 5,320, the average daily attendance ranged from 1 or 2 to 60, that in 673 districts being fewer than 10 and that in 806 districts 30 or more. The total annual operating expenses of such schools increased quite steadily from $900 for those with 3 pupils to $1,600 for those with 45 pupils.

A plan for State aid to carry out a minimum program of $1,200 per classroom unit was outlined by the Michigan station, the units per classroom in general being for 1-room schools, a classroom unit for an average daily attendance of 22 or under and 0.015 unit for each additional pupil; for elementary schools of more than one room, a classroom unit for the first 22 pupils and one twenty-second of an additional unit for each pupil in excess of 22; 44 pupils, 2 classroom units; 84 pupils, 3 classroom units; and over 84 pupils, a classroom unit for each 28 pupils; and high schools, average daily attendance of 42 or fewer a classroom unit for each 14, 63 to 420 pupils 4 classroom units plus 1 unit for each 21 pupils over 63. 420 pupils and over 1 room to each 20. It is estimated that the additional State aid necessary to carry out the plan would be from approximately $1,330,000, with a 5-mill local tax, to $9,122,000, with a 1-mill local tax.

The Colorado study of school financing showed that expenditures for education in 1928 took 50 per cent of the taxes collected by the State and local governments, that 76.9 per cent of such expenditures were from local taxes and other sources, and 19.8 per cent from county taxes, and that 90 per cent were paid from taxes on real estate and general property. The taxable wealth per school child in different counties ranged from $1,913 to $21,850, and the school-tax levies in 1929 from $5.75 to $25.62 per $100 assessed valuation. A more detailed study of Laramie County showed the taxable wealth of school districts of that county ranged from $22,000 to over $16,775,000, the daily attendance from 4 to 2,785 pupils per school, and the annual cost per pupil from $61 to $416. Four districts had less than $50 worth of school property per pupil in attendance, while one had $1,512. While country teachers received, on an average, $1,036 annual salary and had only 4.7 years of experience as compared with salaries of $1,640 and 11.4 years of experience for town and city teachers. the cost of education averaged $147 per pupil in country schools and $120 in town and city schools.

Methods of remedying, in part at least, the conditions now existing, as suggested by stations studying taxation, include raising, through income taxes, part of the funds now raised through taxes on real estate and general property taxes; an increase in the gasoline tax and some similar taxes; the equalization of costs of education from income obtained from State-collected sources; the use of larger units in granting State aid; collection of taxes by county rather than local officers; more careful scrutiny of expenditures; and a reduction of fixed costs, such as interest, by more attention to methods and details of financing.

FARM CREDIT

The large percentage of farmers using farm mortgages and short-time credit, the large amounts of store credit used, especially by tenants, the very high cost of such credit compared with that secured from banks and individuals, the close relationship between amount of credit used and the nature and source of farm income, and the greater readiness of banks to loan for diversified farming than for 1-crop farming were significant findings in studies of farm credit by the Arkansas, Kentucky, and Oklahoma stations. Approximately 50, 60, and 66 per cent, respectively, of the farms studied in the three States were mortgaged. In the Oklahoma study 65 per cent of owners and 86 per cent of the tenants used seasonal credit, of which over 25 per cent was obtained from local stores at an average cost of 32.5 per cent as compared with 11.3 per cent interest for loans secured from banks and individuals. In the counties studied by the Kentucky station, 7.5 to 36.2 per cent of the farmers used store credit. In the two areas studied by the Arkansas station, merchants furnished 4 and 8 per cent, respectively, of the credit to owners and 19 and 41 per cent of that to tenants.

A study of agricultural credit corporations in the State made by the Arkansas station indicated that a margin between income received and interest charged farmers of at least 2.4 per cent of the annual volume of loans is necessary; that ownership interest on the part of patrons is essential to success; and that, while such corpora-

tions have filled a distinct need as emergency institutions, their future value is uncertain under present regulations and conditions.

In a study of long-term bank loans from 1914 to 1927, the Iowa station found that it was not necessary to confine bank loans to those of short maturities, that the banks did not so confine themselves, and that the rapid increase of time deposits since 1920 will permit even longer average maturities than were feasible before the World War.

Credit on side-line purchases in Iowa farmers' elevators were found by the Iowa station to cost credit patrons an average of 7 per cent in strict credit companies and 12 per cent in liberal companies. In addition, about two-thirds of the cost of such credit was borne by the cash and grain patrons. If the burden had been placed entirely on the credit sales, the margin on such sales would have been increased 4.5 per cent in the strict and 12 per cent in the liberal credit companies. Side-line sales constituted only 24 per cent of total sales, but bills receivable for such sales absorbed 21 per cent of the total capital and over 90 per cent of the working capital and cost annually an average of $1,943 per company or 7.8 per cent of the credit sales and 17.3 per cent of the receivables carried. Of the annual average cost, $695 was interest, $686 bad debts, and $562 office and collection expenses.

Registered chattel mortgages in Union County, Ohio, were found by the Ohio station to have increased from 349 in 1910, totaling nearly $105,747, to 2,324 in 1930, totaling nearly $957,500. Of these, 1,521, totaling over $536,000, were rural mortgages. Part of the large increase was due to the fact that chattel-mortgage loan companies tend to require liens on a major portion of a farmer's chattels for small loans, thus compelling implement and other dealers to secure and register mortgages to protect credit formerly extended without chattel security.

PRICES AND PURCHASING POWER

The purchasing power of corn increased steadily at the rate of 0.53 per cent per year from 1866 to 1919, according to a study by the Iowa station. Since the World War the purchasing power has fallen about 25 per cent. The rise in the earlier period was due chiefly to increase in the purchasing power of livestock resulting from the rapid increase in the demand for meat. The fall since the war has taken place in the face of a decrease of about 5 per cent in corn production and was found to be due largely to a 30 per cent decline in the number of horses and mules, a 25 per cent decrease in the purchasing power of hogs and cattle, to changes in livestock-production practices and improvements in corn-production practices, and to the northwestward movement of the Corn Belt. A further slow decline in purchasing power of corn is indicated.

A study of the trends in the cost of production and in the purchasing power of fruits, made by the Michigan station, showed noticeable declines in the margins of profits for apples and peaches. The cost of production of apples in the period 1914–1929 was from 150 to 225 per cent of that for the period 1850–1875, while the purchasing power was only 125 to 175 per cent of that of the former period. The cost of producing peaches in the period 1914–1929 was 180 to 230 per cent of the cost during the period 1850–1875 and the purchasing power 25 to 50 per cent of that of the earlier period. Other fruits showed considerable more evidence of a decline than of an increase in the margin of profit. With margins of profit decreasing, any wide expansion of acreage would be unwise and the only plantings that can be encouraged are those made under exceptionally favorable circumstances where growing and marketing costs are certain to be low.

Definite cycles in the purchasing power of eggs in terms of feed, averaging 30 months, were found by the Pennsylvania station. High-producing flocks (173 eggs per hen per year) were found to be 48 per cent more efficient than low-producing flocks (106 eggs per hen per year) in feed utilization for egg production. During the 20 years studied, the yearly production of a 106-egg hen would have purchased from 88 to 132 pounds of the balanced ration recommended by the station, that of a 154-egg hen from 132 to 202 pounds, and that of a 173-egg hen from 150 to 235 pounds. The feed-purchasing power of eggs ranged from 58.6 per cent of the annual average in October to 116.5 per cent in March, showing that for the average flock the most profitable period is during the spring when eggs are cheap but production is high.

The regular quotations of the State and Federal cooperative crop-reporting service were found by the Missouri station to be reliable indicators of price movements for the State as a

whole. Averages for small areas like counties and, in some instances for larger areas, were not so reliable. The popular conceptions of the variations of prices between towns were found to be greatly exaggerated, although there was a fairly distinct tendency for towns having high or low prices for one commodity to have similar price levels for other products. Freight rates, on the whole, were fully reflected in local prices, but there was great unevenness between individual commodities and towns. Local production, except for commodities like corn and oats, had no well-defined influence on local prices. Size of town had little or no effect until a population of 5,000 people was reached, in which case prices of farm products were usually higher and those of supplies lower. The presence of cooperative agencies did not appear to raise product prices or lower supply prices, and but little relation between the number of local dealers and the local prices was found.

With a feeding period of three or four months, the greatest margin between the cost price of stock hogs and the selling price of the finished hogs was found by the Missouri station to exist when the hogs were bought in the late spring or late fall. The smallest margin existed in the case of summer purchases. The relationship between the prices of stock and of slaughter hogs was found to be fairly constant, the fat-hog prices usually being 30 cents to $1 per hundredweight higher. Stock-hog prices were usually highest at the times of the greatest shipments of such hogs, showing the total supply of hogs on the market to be more influential than the supply of stock hogs alone.

In an analysis of the causes of changes in beef-steer prices, the Idaho station prepared tables covering the period 1910–1929 which show the relationship between the annual steer prices on the Portland market and the number of beef cattle in the far Western States, the direction and amount of the change in beef prices during the preceding year, the Middle West corn-hog ratios the previous fall and the previous spring, and the demands for beef steers. Using these data the station was able to estimate the annual average prices of beef steers on the Portland market for the period (1917 and 1918 omitted) with errors of from only 2 to 60 cents per hundredweight, except for 1927 when the error was $1.84.

Series of prices paid to Maryland producers for farm products during the period 1851–1927 were published by the Maryland station. Similar data for 1866–1930 for Illinois were published by the Illinois station and for the period 1890–1930 in South Dakota by the South Dakota station.

MARKETING

The relation of local market prices of cotton to grade and staple length was studied by the stations in practically all the cotton-growing States.

In nearly all, if not all, cases, prices in the same market on the same day for the same grade and staple length differed considerably and irregularly. In general, the lower grades and short staple lengths brought relatively higher prices.

As a whole, the local markets were found to pass on to the growers only a part of the premiums and discounts paid in the central market for different grades and staple lengths. The Georgia station found that, on an average, less than two-thirds of the premiums in the central markets, and one-third of the discounts for grades above and below middling were passed on to the growers. Growers received only 20 per cent of the central-market premiums for staple lengths over seven-eighths inch. In the case of $\frac{13}{16}$-inch and shorter staples the average price to growers was about the same as for $\frac{7}{8}$-inch cotton, while in the central markets the short staples were penalized $2.50 per bale. In communities producing higher grades and longer staples local prices averaged higher than in communities producing lower grades and shorter staples, showing some tendency for growers of better-quality cotton to be rewarded on a community but not an individual basis.

A cotton-marketing study by the Louisiana station showed about 30 per cent of the central-market premiums and discounts for staple lengths and about 33 per cent of those for grade reflected in local prices. The extent of the reflection varied considerably in the different local markets and in the different types of markets. Type of market appeared to be less significant with regard to grade than to staple-length differences. The adjusted local-market prices of $\frac{13}{16}$-inch staple averaged $2 per bale above central-market prices as compared with 20 cents for $\frac{7}{8}$-inch, $1.40 for $\frac{15}{16}$-inch, and $2.95 for 1-inch cotton. Although there was some direct relation between average length of staple produced and the average spread between local and central market prices, indicating some

recognition of quality on a community basis, the superior quality of cotton was not fully reflected in the average prices paid. A definite tendency for local buyers to class all cotton in one of the three middle classes as to grade and staple length was apparent.

Central cotton markets in South Carolina, according to the study of the South Carolina station covering the 1929–30 season, paid large premiums for grades above Middling and staples over seven-eighths inch and took large discounts on lower grades and staple lengths. Local markets showed some tendency to recognize quality, but discounted short staples and poorer grades much less and paid smaller premiums for longer staples and better grades than did the central markets. The average local prices showed a higher premium for Strict Middling than for Good Middling cotton, while the central-market prices averaged 80 cents per bale lower. In the local markets the discounts for the Strict Good Ordinary and Good Ordinary grades were $8.85 and $7 per bale, respectively, as compared with $13.95 and $18.90, respectively, in the central markets.

A decided tendency for the spread between central and local market prices to widen as the grade and staple length increased was shown in a study by the Florida station of samples collected in 1928. On an average about 33 per cent of the central-market premiums and discounts were passed along to the growers.

A study of the 1929–30 crop by the North Carolina station showed the average differentials from the price for White Middling cotton in local and central markets to be for Good Middling +10 cents and +$2, respectively, Strict Middling +20 cents and +$1.30, Strict Low Middling −$1.05 and −$3.50, and Low Middling −$3.96 and −$7.20. The average differentials from the price for 7/8-inch staple were: 13/16-inch and shorter, −55 cents and −$2.50; 15/16-inch, +15 cents and +$1.35; 1-inch to 1 1/32-inch, +25 cents and +$4.10; and 1 1/16-inch and 1 3/32-inch, +$1.15 and +$8.05.

A study of the June and December pig surveys of the United States Department of Agriculture for the years 1923–1929, made by the Illinois station, indicated that average differences between the estimated pig crop based on intentions to breed and subsequently reported farrowings were 11, 9.7, and 13 per cent, respectively, for Illinois, the Corn Belt, and the United States for the spring crop, and 15.2, 19.9, and 24.8 per cent, respectively, for the fall crop. By correcting the "intentions" estimates for the individual years by the average differences, the "intentions" indicated the reported farrowings with an error of 4.5 per cent for Illinois, 2 per cent for the Corn Belt, and 2.7 per cent for the United States for the spring crop, and 6.3, 7, and 6.8 per cent, respectively, for the fall crop. In five of the seven years in Illinois the changes in the number of pigs farrowed tended to understate the subsequent changes in the number of pigs marketed, the average error being about 5 per cent. A similar tendency existed for the United States as a whole. Winter-market receipts, for both Illinois and for the United States, tended to be alternately larger and smaller by 2-year periods than the changes in the previous spring pig crop would indicate. Summer marketing did not follow a similar sequence, but there was a tendency for relatively high winter receipts to be followed by low summer receipts and vice versa. The study further indicated that changes in the value of products derived from hogs and in the margin taken by packers and other processors were the factors most closely correlated with the levels of hog prices.

In a study of carload shipments of Ohio wheat from 1924–25 to 1928–29, the Ohio station found that, on an average, storage from August to February would have netted 6.5 cents per bushel increase in the price. The lack of a uniform method of arriving at prices for grades above or below No. 2 resulted in a wide range in the prices paid for such grades, the variations in discounts on the same grade often equaling 50 per cent of the margin possible for the local elevator to take.

Various factors entering into consumers' demands in purchasing cantaloupes were studied by the Delaware station. The ability of western melons to compete with local-grown melons, notwithstanding the long distances shipped and the higher transportation costs, was found to be due chiefly to the consistently more uniform size and quality of the western melons. Special attention to marketing operations by the Delaware growers is necessary to overcome this western competition.

From a study of fluid-milk marketing in four cities of the State, the Virginia station concluded that producers are justified in distributing milk if dealer distributors will not pay within 25 cents per gallon of the average resale value of all fluid milk, provided the producers have adequate labor and

equipment to give good service and high-quality milk at a moderate cost without impairing the efficiency of their regular farm work.

Cooperative creameries in North Dakota, studied by the North Dakota station in 1928, paid 47.15 cents per pound for butterfat as compared with 49.81 cents paid by Minnesota plants included in the study, the difference in price being largely due to the difference in quality of butter made. Data from 30 cooperative creameries in northern Minnesota indicated in 1928 that an increase of 34 per cent in the amount of butter scoring 93 or over increased the average price received for butter 1 cent per pound and that such an increase in the butter price resulted in a 2.16 cent per pound increase in the butterfat price. The North Dakota cooperative cream stations handling from 150,000 to 170,000 pounds of butterfat paid their patrons 1.3 cents more per pound in 1927 and 4.7 cents more in 1928 than did those handling from 30,000 to 50,000 pounds.

At least 75 per cent of the demand of Michigan apple consumers, according to a study by the Michigan station, is for a product marketed by only a small percentage of the growers of the State. The average orchard was found to be composed of varieties of which fewer than 50 per cent are readily salable, and only 25 or 30 per cent of the commercial crop grown and packed meets A grade specifications. In Detroit about 80 per cent of the demand was found to be for grade A or better fruit, and only about 21 per cent of the supply for the city is grown in the State.

Surveys and studies of milk marketing in the Los Angeles market were made by the California station, of the New Jersey metropolitan market by the New Jersey stations, of the New York market by the New York (Cornell) station, and of northeastern Ohio by the Ohio station.

Studies of the general and State trends in production, markets, prices, and the outlook for profitable production of barley, olives, and wheat were made by the California station, and of small fruits and hops by the Oregon station.

FARM MANAGEMENT AND COST OF PRODUCTION

A 5-year study of dry farming in eastern New Mexico, made by the New Mexico station, showed that the labor incomes of farmers who raised a considerable acreage of wheat averaged higher but varied more from year to year than did those of farmers who confined themselves to row crops. The farmers having above average receipts from dairy and poultry products had labor incomes from $500 to $1,000 higher and used their labor 25 per cent more completely than did those with less than average receipts from these sources.

Suggestions for the reorganization of cattle ranches to increase net incomes were made by the South Dakota station as a result of a study of the organization and management of such ranches in the western part of the State.

The most efficient size of range beef cattle outfits in Montana, measured by return to the operator and on investment, was found by the Montana station to be between 300 and 800 head. Operating expenses per head tended to decrease as the number of cattle increased up to 500 or 600 head, and then to remain nearly constant. Gross income per head increased up to 400 head and then decreased as the size of the outfit increased. With death losses over 5 per cent there was but little chance of any net return. The lowest cost of production per calf was obtained when 80 per cent of the calves survived.

No great difference in profits from range sheep production under different methods of operation was found by the Arizona station in a study covering the years 1927–1929. There was, however, a wide range in expenses and receipts under the different methods. Based on the conditions during the periods studied the requirements as to capital investment, lamb crop, value of lambs, fleece weights, price of wool, death losses, maintenance and operation per head, cash receipts per head, etc., necessary in order to pay customary managerial salary and 8 per cent on total capital investment were worked out for early-lambing, February-lambing, and May-lambing outfits.

Specialized tobacco farms returned the lowest and dairy-tobacco farms the highest income in 1925 and 1926, according to a study of tobacco farms in the Connecticut River Valley made by the Connecticut (Storrs) station. Even in 1926 when tobacco was 26 cents per pound, the average income of specialized-farm operators was not much above that of farm hands, lack of sufficient acreage being an important factor on the majority of the farms. In a year when tobacco prices yield a profit (about 25 cents per pound), 16

or more cows are needed to obtain a fair income where less than 5 acres of tobacco are grown, 11 to 15 cows with 6 to 10 acres, and 6 to 10 cows with 11 to 15 acres of tobacco. Farmers with less than 5 acres of tobacco also were found to increase their incomes by having 30 to 40 acres in other crops.

The cost of wheat production from 1919 to 1929 on a large-scale production farm in Palouse County, studied by the Washington station, varied from $1.66 per bushel in the crop year 1919–1920 to 75 cents in 1927, averaging 90.3 cents for the period. The profit or loss per bushel ranged from a 7-cent loss in 1921–22 to a 28-cent profit in 1927 and averaged 17.4 cents profit for the period.

In a study of farming systems for the low-precipitation areas of eastern Washington and northern Idaho, the Idaho and Washington stations outlined five cropping systems continuing wheat as the major enterprise but including sweetclover, peas, and alfalfa. On the basis of a 320-acre farm with 300 acres of crop land and the use of 9-horse equipment and stationary thresher, the estimated labor incomes under the different rotations were: For the present 2-year plan, wheat alternating with fallow, $91; peas 1 year, wheat 1 year, $1,422; sweetclover 1 year, wheat 2 years, $835; sweetclover 1 year, wheat 3 years, $1,329; sweetclover 1 year, wheat 2 years, peas 1 year, $758; and alfalfa 3 years, wheat 4 years, and new alfalfa seeded alone 1 year, $609. The estimated acreage that it is possible to handle efficiently with tractors and combined harvester-thresher equipment and the estimated labor income were for the present system, 830 acres and $3,407, respectively; peas and wheat, 538 acres and $4,693; sweetclover and wheat (two years), 585 acres and $3,443; sweetclover and wheat (three years), 780 acres and $6,395; and sweetclover, wheat (two years), and peas, 780 acres and $5,158. With the 4-year clover-wheat-pea rotation, it was found that sheep and dairy cattle may be profitable on a long-time basis, and that hog production would not be profitable unless the price of pork was relatively high as compared with the price of wheat. Poultry and dairy cattle was found to be a better combination than hogs and dairy cattle.

The best farms in the Pee Dee area studied by the South Carolina station averaged 25.3 acres per mule, of which 6.8 acres were in cotton, 3.7 acres in tobacco, and 6.5 acres in corn, as compared with 22.8 acres per mule for all the farms studied and 20 acres on the poorest farms. Average operator's earnings during the period 1923–1928 increased from $780 for farms of 25 acres or less to $1,374 for those of 123 acres or over.

Crop yields were found by the Illinois station to have accounted for $1,007 of the difference in 1929 between the incomes of the 76 most profitable and the 76 least profitable of the 380 farms in the cooperative farm bureau-farm management service project. Efficiency of livestock accounted for $965 of the difference, cost of power and machinery for $193, amount of livestock for $123, cost of labor for $112, and other expenses for $107.

The average cost of producing rice in 1927 on 74 farms studied by the Arkansas station was $42.49 per acre, or 80 cents per bushel. A per acre average of 25.09 hours of man work, 10.58 horse hours, and 4.09 tractor hours was used, with a total cost of $15.43. The group of farms with the lowest labor and power costs used 21.2 hours of man labor, 11.6 horse hours, and 2 to 2.99 tractor hours. With over two tractor hours, man hours also increased, and there was no corresponding decrease in horse hours. Total production costs per acre and per bushel decreased as the acreage in rice increased up to about 250–300 acres.

Only 71 per cent of the 129 small sugarcane farms studied by the Louisiana station in 1930 showed any positive net cash income, and only 30 per cent had sufficient cash income to pay depreciation, family labor, and interest on investment. Size of farm did not markedly affect the net cash income per acre. Both cash and labor incomes increased as the area in sugarcane increased up to about 50 per cent of the crop area. Above 50 per cent, labor and feed expenses rose relatively more rapidly than did gross income. Growing cotton on any considerable proportion of the crop area decreased both net cash and labor incomes.

A definite relation between operator's earnings and number of cows, production per cow, and acreage in crops, on dairy forms in the Richmond area, was found by the Virginia station. The study showed that a 20-cow dairy farm would require one man with some additional labor and an investment of approximately $16,500, and a 60-cow farm four or more men and an investment of practically $48,000. A cropping system including 10 acres of corn for silage and 5 acres for grain, 10 acres of alfalfa, and 18 acres of small-

grain mixture was suggested for the 20-cow farm, and 40 acres of corn for silage and 20 acres for grain, 30 acres of alfalfa, 30 acres of rye for pasture, 30 acres of small-grain mixture, and 5 acres of sorghum for the 60-cow farm.

The average net cost in 1926–1928, on commercial egg farms studied by the Oregon station, was $4.09 per hen, or 28.7 cents per dozen eggs produced, the costs ranging from 22.6 cents per dozen for the best 20 per cent of the flocks to 37.4 cents for the poorest 20 per cent. The costs were 10 cents per dozen lower for the 38 per cent of the flocks averaging 196 eggs per year per hen than for the 12 per cent averaging 128 eggs. It was found that 110 eggs per hen were required to pay bare cash costs and 170 eggs to pay all costs. The most efficient operators obtained 113 eggs per hour of labor and had a labor income of 59 cents per hour, as compared with 23 eggs and 12 cents per hour for the least efficient operators. The former cared for 2,000 hens and the latter 400 hens. The minimum economic unit on a diversified farm was found to be 400 hens, with 600 hens a better unit. For a 1-operator full-time poultry farm 1,200 to 1,500 hens was the minimum economic unit.

An average of 2,215 man hours, 817 horse hours, and 20 truck and tractor hours per 1,000 mature trees was required prior to harvest in apple orchards studied by the New Hampshire station in 1926–1928. Labor required for harvesting and for grading and packing was about equal to that required before harvesting. The estimated net cost prior to harvest, including use of land and appreciation and depreciation of trees, was about $514 per 1,000 boxes normal yield, or $466 per 1,000 boxes actual yield.

Labor and power costs in producing corn in Putnam County, Ohio, were found by the Ohio station, in a study covering the years 1926, 1927, and 1928, to have been $8.19 per acre on farms using horses only and $7.12 on those using tractors for part of the work. The tractor farms averaged 3.2 bushels higher yields and 4 cents less cost per bushel. Use of tractors to the extent of two hours per acre saved 47 per cent of the man labor and 28 per cent of the horse work up to harvest. With fields of 12 acres or more, considerable less time per acre was required in plowing for corn and cultivating corn than with fields of 6 acres or less. The use of 3-horse and 4-horse equipment instead of 2-horse equipment reduced the labor requirements for 45 acres of corn by 18 days. A man performed 37 per cent more production work, and an average day's work was done in 28 per cent less time on the highest labor income farms than on farms in the lowest-income group.

The average cost per acre of cutting and threshing grain on farms studied by the Minnesota station in 1928 and 1929 was $1.53 with an 8-foot, $1.74 with a 10-foot, $1.75 with a 12-foot, and $1.60 with a 16-foot combine. Windrowing cost 46 cents per acre with a 12-foot windrower and 44 cents with a 16-foot machine. Cutting with a binder and threshing with a stationary thresher cost from $3.45 per acre in the northwestern part of the State to $5.53 in the southeastern part. The average rate of harvesting per hour with combines varied from 2.1 acres with 8-foot combines to 4 acres with 16-foot machines.

The average cost of harvesting with combines ranged from $2.02 to $2.27 per acre for all crops harvested in 1927–1929, as compared with costs of from $3.18 to $3.55 for harvesting with binders and threshers, in studies reported by the Indiana station. The cost per bushel was less with combines when more than 130–140 acres were harvested.

Investigations of the costs and the amount of labor required in harvesting corn by different methods were studied by the Illinois and Indiana stations. Hand husking in Illinois averaged $5.11 per acre, or 10.4 cents per bushel, and required 5.23 hours of man labor, for the period 1920–1928. In Indiana the cost in 1929 was $3.98 per acre, or 10 cents per bushel, and 4.75 hours of man labor were used. With 1-row huskers the costs averaged $3 55 per acre, or 7.1 cents per bushel, in Illinois, in 1928–29, and $3.41 per acre, or 8.8 cents per bushel, in Indiana in 1929. The man-labor requirements were 2.72 hours and 2.83 hours, respectively. With 2-row huskers, the average cost was $2.98 per acre, or 6 cents per bushel, in Illinois, and $2.42 per acre, or 5.9 cents per bushel, in Indiana, the man-labor requirements being 2.21 and 2.06 hours, respectively, in the two States. The Illinois study showed that family labor made up about 70 per cent of the labor with machines and only 30 per cent with hand husking. The Illinois study showed the cost per acre and the man-labor requirement for other methods of harvesting to be: For cutting for silage with a field harvester, $10.06 and 10.06

hours; for cutting for silage with stationary cutter, $9.85 and 13.44 hours; and for cutting and shocking, $5.61 and 16.6 hours.

COOPERATION

A study of the relations of members to coperative livestock-shipping associations, made by the Illinois station, brought out that 36 per cent of owner members and 39 per cent of tenant members had given no thought to the responsibility of members to their associations, that 51 per cent and 65 per cent, respectively, had not previously belonged to an association, and that 69 per cent and 81 per cent, respectively, reported larger returns as a result of the associations. In six cooperative purchasing associations studied by the Pennsylvania station, 17 per cent of the members made 25 per cent or less of their purchases of commodities handled by the association through the association, 14 per cent from 26 to 50 per cent, 11 per cent from 51 to 75 per cent, and 58 per cent, 76 per cent or over. The percentages for nonmembers were 60, 16, 5, and 19 per cent, respectively. Of the members, only 58 per cent talked to neighbors about their organization, only 43 per cent inquired about prices before buying through the cooperatives, 92 per cent believed the associations lowered prices of supplies, 81 per cent that abandonment of the organizations would result in an increase of such prices, 92 per cent liked the cash-at-car-door method of selling, and 72 per cent were satisfied with the services of the associations.

A study of the operations since 1920 of the community apple-packing house established by the West Virginia Legislature and operated by the West Virginia College of Agriculture showed the average cost of packing per barrel was 32 cents, of which approximately 10 cents was overhead expense. During the first eight years only 58.5 per cent of the apples brought to the plant were packed in containers. It is estimated that through improved cultural practices and control of insects and diseases, the percentage of culls would have been reduced from 41.5 to 12.5, and the returns to growers increased over $88,000. Largely because of the fruit standardization inaugurated by the community packing house, the number of Federal-inspected cars of apples in the eastern Panhandle section of the State increased from 40 in 1922 to 2,300 in 1928.

Too many local associations, and costs out of line with the incomes and services received, were found by the Louisiana station in a study of the financing of strawberry production and marketing in the State. It was recommended that the existing associations be consolidated or reorganized into single strong associations at each of the main shipping points, and that a central selling organization made up of the local associations be formed to handle sales and accounting, to maintain a credit corporation, to purchase supplies, fertilizer, and feed, and to put all transactions on a cash basis.

PART-TIME FARMING

Massachusetts has at least 60,000 part-time farming enterprises, and a third or more of the agricultural production of the State comes from such enterprises, according to a study made by the Massachusetts station. The investigation indicated that the part-time farming is largely on submarginal land and so does not compete actively with regular agriculture for land, that it is increasing tax receipts in decadent farming areas, and that it is securing for wage earners a certain economic stability and making possible better food and housing conditions. The development is going hand in hand with better transportation facilities, shorter hours in industries, and the location of industrial plants in small towns and communities.

FRED G. HARDEN.

RURAL SOCIOLOGY

Investigations in rural sociology continued to cover a wide range of subjects, although most of the investigations were confined to rather limited areas. Studies of population, rural health, rural organizations and group activities, young people's organization, and standards and cost of living were each carried on at two or more stations.

The population studies reported by the Iowa and Michigan stations confirmed the results from other similar studies in showing that the number of the rural population in the producing-age group—20 to 45 years—has been reduced by migration to a point considerably below the normal distribution, and indicating that such a condition, if continued, will result not only in less production of commodities per individual but also in a lowering of the future rural birth rate.

Notwithstanding the increase in spatial and occupational mobility of

the farm population during the last 50 years, the Ohio station found such population to be still very stable. Sons and daughters of farmers having larger farm businesses and of farmers who had farmed all their lives were found to be staying on the farm in much larger proportion than the children of farmers with smaller businesses or of parents who have engaged in other occupations during all or part of their lives. (See below.)

The studies of the South Dakota and Ohio stations further emphasized the findings in other studies in that the rural sections as a whole are inadequately supplied with doctors, dentists, hospitals, and public-health services. While the rural counties of South Dakota had relatively fewer specialists, a considerably higher percentage of the rural than of the urban physicians were graduates of first-class schools.

The more successful farmers in Illinois were found to affiliate with a larger number and greater variety of rural organizations, especially those having more than community-wide activities, than did the less successful farmers. Also practically all the men belonging to economic organizations were found to be members of organizations for other purposes.

The Minnesota study of the changes in farm trading centers, 1905–1929, showed that the extensive trade centers have developed as additions to elementary trade centers rather than as substitutes for them. The development of the extensive centers has resulted primarily from the changes in transportation and in farm-family standards of living and is tending to break down not only the cohesion between families in the same area but between members of the same family. (See also p. 107.)

Country boys who enter farming are likely to have an eighth-grade education, according to a study by the Ohio station. Those who dropped out of school before finishing the eighth grade tended to become nonagricultural laborers. While about 20 per cent of the high-school graduates entered farming, only a small proportion of the boys leaving school in the high school did so.

A survey of educational services made by the Michigan station showed that higher percentages of the school population were enrolled in schools and in high schools in rural counties than in counties where less than 50 per cent of the population was rural.

Population studies.—Deficiency in the numbers of the rural population in the producing-age groups were found in studies by the Iowa and Ohio stations. The Ohio study showed relatively fewer persons under 5 years of age than in the 5-year to 9-year and the 10-year to 19-year groups, and in the 5-year to 9-year group than in the 10-year to 14-year group. The Iowa investigation, on the other hand, showed that with only 41 per cent of the population of the State in 1920 on farms, 49.4 per cent of the persons under 5 years of age were on farms and that the percentage did not decrease to approximately 41 per cent again until the 20-year to 24-year group was reached. The ratio of males to females in the farm population increased from 104.1 in the under-5-year group to 113.6 in the 15-year to 19-year group, held nearly constant (111.5 to 112.3) in the 20-year to 24-year to the 35-year to 44-year groups, then increased to 131.2, 146.5, and 145.1, respectively, in the next three 10-year group. The ratios in the village population decreased from 102.1 in the under-5-year group to 91 in the 15-year to 19-year group and 91.3 in the 20-year to 24-year group and were 100.7, 104.8, 101.1, and 104.6, respectively, in the next four 10-year groups. In the urban population there was a decrease from 102.8 in the under-5-year group to 88.2 in the 20-year to 24-year group, and the percentages in the next five 10-year groups were 99.8, 100.7, 104.5, 102.9, and 99.6, respectively.

A study by the Ohio station of the movement of country population based on data from 1,275 families in eight selected areas in Ohio showed that of the farm operators 93 per cent were born in the open country, and 46 per cent in the township and 62 per cent in the county in which they resided at the time of the survey. Nearly 25 per cent of the households had lived on only one farm, 50 per cent in one township, and 67 per cent in only one county. Of the male children between 15 and 61 years of age, 36 per cent started for themselves as farm owners, tenants, or laborers, 45 per cent became nonagricultural laborers, and 18 per cent entered business, the professions, or clerical or sales work. Of those becoming farmers, 80 per cent remained such and 6 per cent of the others returned to the farm. Thirty-nine per cent of the sons and 37 per cent of the daughters of farmers stayed on the farm, and 10 and 16 per cent, respectively, of the sons and daughters of nonagricultural parents went to farms. The percentage of sons becoming farmers rose steadily from 25

per cent of those whose fathers had a farm business using a total of 99 man-work units to 58 per cent for those using 500 or more such units. Forty-three per cent of the sons and 47 per cent of the daughters of parents who had always farmed were on farms, as compared with 9 and 12 per cent for those whose parents had never farmed.

Rural health.—In a study of public-health services in its State, the Michigan station recorded an average of 1,072 persons per physician, 3,974 per dentist, 767 per hospital bed, and 38,335 per public-health nurse in counties having 75 to 100 per cent rural population, as compared with 1,065, 2,250, 246, and 12,454 in counties with less than 50 per cent rural population. In three counties there were more than 8,000 persons per dentist. A survey of the rural health situation in its State, made by the South Dakota station, showed the number of persons per physician to be 1,344 in 14 strictly rural counties, as compared with 841 in 14 urban counties. Sixty-three per cent of the physicians in the rural counties and 54 per cent of those in the urban counties were graduates of first-class schools. No hospitals were found in 38 counties containing 37.8 per cent of the population of the State, and for South Dakota as a whole there was only one hospital bed to each 2,290 persons, about one-ninth of what the American Hospital Association deems adequate.

Rural organizations and group activities.—Organizations found in 68 communities in 6 counties studied by the Illinois station included 227 economic, 361 educational, 313 religious, and 242 social groups. The number of country people attending meetings during a year in 10 town-country communities studied by the Michigan station was 15.5 times the estimated population of the trade areas. The attendance of town people was 40.5 times the population of the towns. Size of the community had little effect on this index. There were 3.5 times as many meetings designed for men as for boys and 5 times as many for women as for girls under 15 years of age. Ninety-seven per cent of the men in 2,548 farm families, studied by the same station, who belonged to economic organizations were also members of noneconomic organizations. The more successful farmers tended to be identified with a larger number and variety of organizations, particularly those having more than community-wide activities. Women tended to affiliate with as many organizations as their husbands, and children of parents not members of organizations were less likely to belong to organizations for youths.

Social contacts (exposure to group influence for one hour) made during a year by 70 farm families studied by the Missouri station, ranged from 150 to 1,500, averaging 691.5, of which 90.5 per cent were provided by unorganized activities. The average numbers of contacts and the percentages arising from unorganized activities ranged from 779 and 93.2 per cent for the renters to 612.8 and 88.5 per cent for the owners. On the basis of the influence of such factors as social contacts, recreation, reading and education, quality of diets, labor income, and expenditures, 41.2 per cent of the owner, 58 per cent of the owner renter, and 17.6 per cent of the tenant families were given a superior rating, and 26.4 of the owner, 15.9 of the owner renter, and 41.2 per cent of the renter were given a below-average rating.

The service centers for 90 per cent of the farmers in 59 communities studied by the Michigan station were places of less than 2,500 population, and more than half the centers had considerably fewer than 1,000 people. Since a population of 1,200 to 1,500 people is necessary to support an accredited high school, good stores, markets, financial facilities, efficient professional services, and good churches, many of the smaller towns must accept a neighborhood status and adjustments must be made on a new and more effective basis of a larger population, greater resources, mutuality of town and country control and direction of institutions, and a genuine cooperation of town and country people.

Outstanding characteristics of the changes in farm trade centers in Minnesota from 1905 to 1930, other than those mentioned on page 106, have been determined by the Minnesota station. A division of labor between retail trading communities has been brought about and the complexity of rural social organizations greatly increased, the elementary center tending to keep much of its centralization of interests and simplicity while the competitive shopping areas are confused and fluctuating and the total retail trading organizations of the farm have become more complex and decentralized. The development of contemporary retail trading relations in the country districts came about primarily because of changes in transportation and in material standards of living of the farm

families. The changes in trading relations were associated with an increase in the luxuriousness of material standards of living and a tendency for the nonmaterial phases to stay constant or to decline with the rapid improvements in material standards.

Rural education.—A survey of educational services by the Michigan station showed that from 60.2 to 92.3 per cent of the school population was enrolled in schools and 11.4 per cent in high schools in the counties having from 75 to 100 per cent of rural population, as compared with 50.9 to 87.5 per cent and 12.5 per cent, respectively, in the counties with less than 50 per cent of the population rural.

Of the children between 6 and 18 years of age in the 70 families in a community studied by the Missouri station, 39.1 per cent were in school grades standard for their ages, while 37.5 were in grades below and 23.4 per cent in grades above standard. The educational indexes of the families showed that the highest one-third had the education represented by from slightly above to almost 2 years above standard for the children and from high school to 2½ years college attendance for adults. The middle third represented slightly more than 1 year below standard for the children and approximately eighth-grade graduation for the adults. The lowest third represented 2 to 3 years below standard for the children and, in general, grammar-school attendance for the adults.

Miscellaneous. — Other research reported during the year included a sociological study of a New York village and surrounding country and an investigation of communities in a New York county by the New York (Cornell) station, a study of organization affecting farm youth in a Pennsylvania township by the Pennsylvania station, standard of living and family-expenditure studies by the Illinois, Iowa, Kentucky, Nebraska, and Ohio stations, play and recreation of children and youths in selected areas of South Carolina by the South Carolina station, and 4-H club work by the West Virginia, Virginia, and New York (Cornell) stations.

FRED G. HARDEN.

PUBLICATIONS OF THE STATIONS (1930–31)

The publications of the experiment stations show the wide scope and variety of their work. Of the 931 station publications of the regular series received by the Office of Experiment Stations during the fiscal year ended June 30, 1931, 15 related to meteorology, 48 to soils and fertilizers, 93 to field crops, 92 to horticulture, 15 to forestry, 74 to plant diseases, 45 to entomology and zoology, 30 to foods and human nutrition, 10 to rural home management, 118 to animal production, 32 to dairying, 34 to diseases of livestock, 45 to agricultural engineering, and 145 to economics and sociology, and 135 were annual reports and miscellaneous publications of various kinds. These publications deal with most, if not all, of the major problems of the farm and the farm home. Their findings have been currently reviewed in Experiment Station Record.

The volume and variety of station publications are increasing from year to year. This is especially true of publications in scientific and technical journals and those of more popular and ephemeral nature. During the past year, according to records kept by the Office of Experiment Stations, the stations published 1,717 articles in 69 technical and scientific journals and contributed or collaborated in 64 articles published in the Journal of Agricultural Research. Progress is being made not only in securing greater scientific recognition, but wider practical application of the results of station work. It is evident that the publications are being more carefully prepared with these ends in view.

The amount reported as expended for publications by the experiment stations during the year ($371,312) shows a substantial increase over the amount ($322,863) used for this purpose during the preceding year.

The following is a classified list of the 931 station reports, bulletins, and miscellaneous publications received by the office during the year:

METEOROLOGY

The climate of Arizona. H. V. Smith. Ariz. Sta. Bul. 130, p. 336–416, illus. 1930.

Meteorological observations. C. I. Gunness et al. Mass. Sta. Met. Buls. 498–509, 4 p. each. 1930–1931.

Climate as it affects crops and ranges in New Mexico. C. E. Linney, F. Garcia, and E. C. Hollinger. N. Mex. Sta. Bul. 182, 84 p., illus. 1930.

Establishing snow courses and making snow surveys. G. D. Clyde. Utah Sta. Circ. 91, 16 p., illus. 1930.

SOILS AND FERTILIZERS

Caliche in Arizona. J. F. Breazeale and H. V. Smith. Ariz. Sta. Bul. 131, p. 417–441, illus. 1930.

Maintenance of moisture-equilibrium and nutrition of plants at and below the wilting percentage. J. F. Breazeale. Ariz. Sta. Tech. Bul. 29, p. 136–177, illus. 1930.

The base exchange property of organic matter in soils. W. T. McGeorge. Ariz. Sta. Tech. Bul. 30, p. 179–213, illus. 1930.

Organic compounds associated with base exchange reactions in soils. W. T. McGeorge. Ariz. Sta. Tech. Bul. 31, p. 215–251. 1931.

Concentration of certain constituents of the soil solution under orchard conditions. E. L. Proebsting. Hilgardia [Calif. Sta.], vol. 5, no. 3, p. 35–59, illus. 1930.

Establishment and succession of vegetation on different soil horizons. J. D. Sinclair and A. W. Sampson. Hilgardia [Calif. Sta.], vol. 5, no. 7, p. 155–174, illus. 1931.

Secular and seasonal changes in soils. J. S. Burd and J. C. Martin. Hilgardia [Calif. Sta.], vol. 5, no. 15, p. 455–509, illus. 1931.

Fertilizer problems and analysis of soils in California. D. R. Hoagland. Calif. Sta. Circ. 317, 16 p. 1930.

Effects of clover and alfalfa in rotation. Part II. W. P. Headden. Colo. Sta. Bul. 362, 131 p., illus. 1930.

Effects of clover and alfalfa in rotation. Part IV. W. P. Headden. Colo. Sta. Bul. 364, 77 p., illus. 1930.

The soils of Connecticut. Progress report of investigations, 1924–1930. M. F. Morgan. Conn. State Sta. Bul. 320, p. 827–911, illus. 1930.

The mechanism of buffer action in soils. P. B. Myers and G. M. Gilligan. Del. Sta. Bul. 166, 37 p., illus. 1930.

Response of Illinois soils to systems of soil treatment. F. C. Bauer. Ill. Sta. Bul. 362, p. 435–514c, illus. 1930.

Crop yields from Illinois soil experiment fields in 1930, together with a general summary for the rotation periods ending in 1930. F. C. Bauer. Ill. Sta. Bul. 370, p. 214–264, illus. 1931.

Edwards County soils. E. A. Norton, R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 46, 69 p., illus. 1930.

Piatt County soils. R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 47, 56 p., illus. 1930.

Effingham County soils. E. A. Norton, R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 48, 55 p., illus. 1931.

A soil management program for Carrington loam. W. H. Stevenson et al. Iowa Sta. Bul. 276, p. 66–84, illus. 1931.

The production of artificial farm manures. F. B. Smith, W. H. Stevenson, and P. E. Brown. Iowa Sta. Research Bul. 126, p. 166–195, illus. 1930.

The effects of artificial farm manures on soils and crops. F. B. Smith and P. E. Brown. Iowa Sta. Research Bul. 127, p. 197–236. 1930.

Microbiological studies of some typical Iowa soil profiles. P. E. Brown and T. H. Benton. Iowa Sta. Research Bul. 132, p. 361–420, illus. 1930.

Nitrate assimilation in soils. F. B. Smith and P. E. Brown. Iowa Sta. Research Bul. 135, p. 33–63. 1931.

Soil survey of Iowa.—Carroll County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 60, 64 p., illus. 1930.

Soil survey of Iowa.—Howard County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 61, 64 p., illus. 1930.

Soil survey of Iowa.—Warren County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 62, 72 p., illus. 1930.

Soil survey of Iowa.—Chickasaw County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 63, 72 p., illus. 1930.

Soil survey of Iowa.—Kossuth County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 64, 64 p., illus. 1930.

Soil survey of Iowa.—Clayton County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 65, 72 p., illus. 1930.

A study of factors influencing inoculation experiments with Azotobacter. P. L. Gainey. Kans. Sta. Tech. Bul. 26, 66 p. 1930.

A study on the influence of climate upon the nitrogen and organic matter content of the soil. H. Jenny. Mo. Sta. Research Bul. 152, 66 p., illus. 1930.

Soils of Blaine County. L. F. Gieseker. Mont. Sta. Bul. 228, 64 p., illus. 1930.

Phosphate deficiency in the soils of Montana. A preliminary report. I. J. Nygard. Mont. Sta. Bul. 240, 32 p., illus. 1931.

The preservation of manure under arid climatic conditions. H. N. Watenpaugh. N. Mex. Sta. Bul. 190, 8 p., illus. 1931.

The chemical composition of New York soils. J. A. Bizzell. N. Y. Cornell Sta. Bul. 513, 25 p., illus. 1930.

Soil and field-crop management for Chenango County, New York. A. F. Gustafson, H. O. Buckman, and H. P. Cooper. N. Y. Cornell Sta. Bul. 514, 82 p., illus. 1930.

Fertilizer tests of several soil types. T. L. Lyon. N. Y. Cornell Sta. Bul. 520, 19 p., illus. 1931.

Lysimeter experiments.—III, Records for tanks 3 to 12 during the years 1910 to 1924, inclusive. T. L. Lyon, J. A. Bizzell, B. D. Wilson, and E. W. Leland. N. Y. Cornell Sta. Mem. 134, 72 p. 1930.

Lysimeter investigations.—I, Nitrogen and water relations of crops in legume and non-legume rotations. R. C. Collison and J. E. Mensching. N. Y. State Sta. Tech. Bul. 166, 90 p., illus. 1930.

Influence of various non-nitrogenous compounds on the growth of certain bacteria in soils of low productivity. H. J. Conn and M. A. Darrow. N. Y. State Sta. Tech. Bul. 172, 40 p. 1930.

Preparation of soil profiles for exhibition and soil study. R. C. Collison and J. D. Harlan. N. Y. State Sta. Tech. Bul. 173, 8 p., illus. 1930.

Chemical composition of the soils of McHenry County. T. H. Hopper and H. L. Walster. N. Dak. Sta. Bul. 240, 46 p., illus. 1930.

The chemical composition of some chernozem-like soils of North Dakota. T. H. Hopper, L. L. Nesbitt, and A. J. Pinckney. N. Dak. Sta. Bul. 246, 72 p., illus. 1931.

Increasing the profits from phosphates for Tennessee soils. C. A. Mooers. Tenn. Sta. Circ. 34, 4 p. 1931.

Occurrence of nitrites in soils. G. S. Fraps and A. J. Sterges. Tex. Sta. Bul. 412, 15 p. 1930.

Possibilities of sulphur as a soil amendment. G. S. Fraps. Tex. Sta. Bul. 414, 56 p. 1930.

A chemical and microbiological study of Lufkin fine sandy loam in relation to productiveness. E. B. Reynolds. Tex. Sta. Bul. 421, 30 p. 1931.

Determination of soil moisture by the method of multiple electrodes. W. H. McCorkle. Tex. Sta. Bul. 426, 20 p., illus. 1931.

Muck soil investigations. Progress report, Sanpete County Experimental Farm, 1927–30, inclusive. L. Wilson and G. Stewart. Utah Sta. Bul. 224, 24 p., illus. 1931.

FIELD CROPS

Growing alfalfa in Illinois. W. L. Burlison, O. H. Sears, and J. C. Hackleman. Ill. Sta. Bul. 349, p. 409–448, illus. 1930.

A comparison of alfalfa strains and seed sources for Michigan. C. R. Megee. Mich. Sta. Spec. Bul. 211, 8 p., illus. 1931.

Alfalfa as a rotation crop. P. E. Miller and R. O. Bridgford. Minn. Sta. Bul. 265, 18 p., illus. 1930.

Alfalfa trials at the North Central Experiment Station. O. I. Bergh. Minn. Sta. Bul. 267, 19 p., illus. 1930.

Irrigated alfalfa in Montana. J. E. Norton. Mont. Sta. Bul. 245, 27 p., illus. 1931.

Experiments with alfalfa, clover, and timothy for hay in New Jersey. H. B. Sprague, E. E. Evaul, H. W. Reuszer, and N. F. Farris. N. J. Stas. Bul. 512, 38 p., illus. 1930.

Alfalfa-seed production. J. W. Carlson and G. Stewart. Utah Sta. Bul. 226, 54 p., illus. 1931.

Barley in Colorado. D. W. Robertson et al. Colo. Sta. Bul. 371, 37 p., illus. 1930.

The date to plant corn in Colorado. D. W. Robertson, A. Kezer, and G. W. Deming. Colo. Sta. Bul. 369, 8 p., illus. 1930.

Corn production in the Coastal Plain of Georgia. W. J. Davis. Ga. Coastal Plain Sta. Bul. 14, 15 p., illus. 1930.

Corn growing in Michigan. H. C. Rather and J. R. Duncan. Mich. Sta. Spec. Bul. 210, 35 p., illus. 1931.

Double-crossed corn in Minnesota. H. K. Hayes, H. E. Brewbaker, and F. R. Immer. Minn. Sta. Bul. 260, 16 p., illus. 1930.

Double-crosses of corn for distribution in Minnesota. H. K. Hayes, I. J. Johnson, and R. F. Crim. Minn. Sta. Bul. 275, 14 p., illus. 1931.

Genetical and cytological studies of Mendelian asynapsis in *Zea mays*. G. W. Beadle. N. Y. Cornell Sta. Mem. 129, 23 p., illus. 1930.

A gene in maize for supernumerary cell divisions following meiosis. G. W. Beadle. N. Y. Cornell Sta. Mem. 135, 12 p., illus. 1931.

Planting rates for early varieties of corn. P. J. Olson. N. Dak. Sta. Circ. 43, 8 p., illus. 1930.

Results of cotton variety tests in Alabama for the period 1925–1929, inclusive. H. B. Tisdale and J. T. Williamson. Ala. Sta. Circ. 56, 3 p. 1930.

Field experiments with cotton. R. S. Hawkins. Ariz. Sta. Bul. 135, p. 553–581, illus. 1930.

Cotton spacing.—II, Effect of blooming on earliness, fruit set and yield. J. O. Ware. Ark. Sta. Bul. 253, 64 p. 1930.

Cooperative fertilizer experiments with cotton. M. Nelson. Ark. Sta. Bul. 255, 44 p., illus. 1930.

Cotton variety tests, 1930. H. K. Brabham and G. A. Hale. Ga. Sta. Circ. 90, 4 p. 1930.

Cotton fertilizer experiments, 1930, sources of nitrogen, supplements, and time and method of application. G. A. Hale. Ga. Sta. Circ. 91, 4 p. 1930.

Cotton production in the Coastal Plain of Georgia. W. J. Davis. Ga. Coastal Plain Sta. Bul. 13, 29 p., illus. 1930.

Cotton variety summary, 1926–1930. J. F. O'Kelly and W. W. Hull. Miss. Sta. Bul. 288, 8 p. 1930.

Commercial fertilizers for cotton, 1925–1930. [W. W. Hull et al.] Miss. Sta. Bul. 289, 30 p., illus. 1931.

Cotton inheritance studies: Lint percentage. J. F. O'Kelly and W. W. Hull. Miss. Sta. Tech. Bul. 18, 15 p., illus. 1930.

Cotton production in Missouri. B. M. King. Mo. Sta. Bul. 299, 34 p., illus. 1931.

Cotton varieties. J. C. Overpeck and W. T. Conway. N. Mex. Sta. Bul. 181, 13 p. 1930.

Biometrical analysis of upland cotton grown at Stillwater, Oklahoma. F. Griffee, L. L. Ligon, and L. H. Brannon. Okla. Sta. Bul. 187, 32 p. 1929.

Methods of ginning in relation to the grade and staple of cotton. D. T. Killough and G. T. McNess. Tex. Sta. Bul. 416, 32 p., illus. 1930.

Varieties of cotton for north Texas. P. B. Dunkle. Tex. Sta. Bul. 417, 31 p. 1930.

Winter cover crop experiments at the Pee Dee Experiment Station. E. E. Hall, W. B. Albert, and S. J. Watson, jr. S. C. Sta. Circ. 42, 14 p., illus. 1930.

Small grain production in the Coastal Plain of Georgia. W. J. Davis. Ga. Coastal Plain Sta. Bul. 15, 11 p., illus. 1930.

Grains for the cut-over lands of northern Idaho. J. H. Christ. Idaho Sta. Bul. 178, 16 p., illus. 1931.

The effect of delayed harvest upon yield of grain. L. C. Burnett and A. L. Bakke. Iowa Sta. Research Bul. 130, p. 302–340, illus. 1930.

Small grain varieties in Minnesota. H. K. Wilson and A. C. Arny. Minn. Sta. Bul. 264, 83 p., illus. 1930.

A cereal variety survey of Oregon. D. D. Hill. Oreg. Sta. Circ. 97, 16 p., illus. 1930.

The production of cereals under irrigation in Washington. H. P. Singleton. Wash. Col. Sta. Bul. 240, 20 p., illus. 1930.

The carbohydrate metabolism of *Stipa pulchra*. A. W. Sampson and E. C. McCarty. Hilgardia [Calif. Sta.], vol. 5, no. 4, p. 61–100, illus. 1930.

Growth and yield of certain Gramineae as influenced by reduction of photosynthetic tissue. K. W. Parker and A. W. Sampson. Hilgardia [Calif. Sta.], vol. 5, no. 10, p. 361–381, illus. 1931.

Effects of irrigation with sewage effluent on the yields and establishment of Napier grass and Japanese cane. W. E. Stokes, W. A. Leukel, and R. M. Barnette. Fla. Sta. Bul. 215, 18 p. 1930.

Growth, behavior and maintenance of organic foods in Bahia grass. W. A. Leukel and J. M. Coleman. Fla. Sta. Bul. 219, 56 p., illus. 1930.

Maryland grasses. J. B. S. Norton. Md. Sta. Bul. 323, p. 251–326, illus. 1930.

Reed canary grass for meadows and pastures. A. C. Arny, R. E. Hodgson, and G. H. Nesom. Minn. Sta. Bul. 263, 27 p., illus. 1930.

Growing orchard grass in south Missouri. C. A. Helm. Mo. Sta. Bul. 294, 11 p., illus. 1930.

The chemical composition of some North Dakota pasture and hay grasses. T. H. Hopper and L. L. Nesbitt. N. Dak. Sta. Bul. 236, 38 p., illus. 1930.

Impurities of North Dakota *Bromus inermis* seed. O. A. Stevens. N. Dak. Sta. Bul. 247, 16 p., illus. 1931.

Experiments with hay crops in Alabama. D. G. Sturkie and R. Y. Bailey. Ala. Sta. Circ. 58, 18 p., illus. 1931.

Kudzu in Alabama. R. Y. Bailey and E. L. Mayton. Ala. Sta. Circ. 57, 10 p., illus. 1931.

Oat varieties in Colorado. D. W. Robertson et al. Colo. Sta. Bul. 370, 34 p., illus. 1930.

Columbia oats, a new variety for Missouri. L. J. Stadler and R. T. Kirkpatrick. Mo. Sta. Bul. 296, 12 p., illus. 1931.

Variety tests of oats, barley, and spring wheat. T. A. Kiesselbach and W. E. Lyness. Nebr. Sta. Bul. 253, 23 p., illus. 1931.

Lodging in oats and wheat. F. A. Welton and V. H. Morris. Ohio Sta. Bul. 471, 88 p., illus. 1931.

Effect of calcium and phosphorus content of various soil series in western Washington upon the calcium and phosphorus composition of oats, red clover and white clover. H. F. Holtz. Wash. Col. Sta. Bul. 243, 45 p. 1930.

Pasture improvement. G. L. Schuster. Del. Sta. Bul. 164, 17 p., illus. 1930.

Top-dressing old pastures. F. S. Prince, P. T. Blood, and G. P. Percival. N. H. Sta. Circ. 35, 12 p., illus. 1930.

Pasture experiments. T. E. Odland, C. V. Wilson, H. O. Henderson, and E. P. Deatrick. W. Va. Sta. Bul. 235, 32 p., illus. 1930.

Sources of nitrogen for potato fertilizers in Aroostook County. B. E. Brown, F. V. Owen, and E. R. Tobey. Me. Sta. Bul. 354, 38 p., illus. 1930.

Fertilizer work with Irish potatoes. L. M. Ware. Miss. Sta. Circ. 92, 4 p. 1930.

Rate of planting potatoes with some reference to sprouting habit and size of plants. J. Bushnell. Ohio Sta. Bul. 462, 20 p., illus. 1930.

Potato growing in the irrigated districts of Washington. H. J. Jensen and O. M. Morris. Wash. Col. Sta. Bul. 246, 30 p., illus. 1931.

The artificial reseeding of New Mexico ranges. C. P. Wilson. N. Mex. Sta. Bul. 189, 37 p., illus. 1931.

Grain sorghum date-of-planting and spacing experiments. R. E. Karper, J. R. Quinby, D. L. Jones, and R. E. Dickson. Tex. Sta. Bul. 424, 71 p., illus. 1931.

The Tokio soybean. C. A. Mooers. Tenn. Sta. Circ. 35, 4 p. 1931.

Soil fertilization for sugar beets. J. Tyson and M. M. McCool. Mich. Sta. Spec. Bul. 205, 31 p., illus. 1930.

Influence of soil conditions, fertilizer treatments, and light intensity on growth, chemical composition, and enzymic activities of sugar beets. J. Tyson. Mich. Sta. Tech. Bul. 108, 44 p., illus. 1930.

Better sugar-beet culture for Utah. G. Stewart and D. W. Pittman. Utah Sta. Circ. 93, 32 p., illus. 1931.

The production and storage of sweet potatoes. J. C. C. Price. Miss. Sta. Bul. 279, 20 p., illus. 1930.

Chemical investigations of the tobacco plant.—I, A preliminary study of the non-volatile organic acids of tobacco leaves. H. B. Vickery and G. W. Pucher. Conn. State Sta. Bul. 323, p. 151–202, illus. 1931.

Chemical investigations of the tobacco plant.—II, The chemical changes that occur during the curing of Connecticut shade-grown tobacco. H. B. Vickery and G. W. Pucher. Conn. State Sta. Bul. 324, p. 203–240, illus. 1931.

Tobacco substation at Windsor, report for 1930. P. J. Anderson, T. R. Swanback, O. E. Street, et al. Conn. State Sta. Bul. 326, p. 351–450, illus. 1931.

The potassium, chlorine and sulfate content of Kentucky tobacco as related to grade. O. M. Shedd. Ky. Sta. Bul. 308, p. 445–471. 1930.

The effects of certain soil conditions on the yield and quality of Burley tobacco, results from a field survey. C. A. Mooers. Tenn. Sta. Circ. 33, 4 p. 1930.

The germination of tobacco seed. J. Johnson, H. F. Murwin, and W. B. Ogden. Wis. Sta. Research Bul. 104, 15 p., illus. 1930.

The relation of nitrate nitrogen and nitrification to the growth of tobacco following timothy. R. P. Thomas. Wis. Sta. Research Bul. 105, 28 p., illus. 1930.

Crops to replace spring wheat in northern Idaho. H. W. Hulbert. Idaho Sta. Bul. 177, 11 p. 1931.

Wheat varieties under irrigation. L. Powers. Mont. Sta. Bul. 234, 42 p., illus. 1930.

Varietal tests with wheat, oats, barley, rye, and buckwheat. M. M. Hoover and R. J. Garber. W. Va. Sta. Bul. 237, 12 p., illus. 1930.

Methods of spring wheat tillage. A. L. Nelson. Wyo. Sta. Bul. 173, 14 p., illus. 1930.

Dry-farming investigations in northeastern New Mexico. J. Carter, jr. N. Mex. Sta. Bul. 191, 16 p., illus. 1931.

A quarter century of dry-farm experiments at Nephi, Utah. A. F. Bracken and G. Stewart. Utah Sta. Bul. 222, 44 p., illus. 1930.

Some rotation experiments at the Ohio Agricultural Experiment Station, Wooster, Ohio. Ohio Sta. Spec. Circ. 31, 4 p. 1930.

Fertilizer and crop rotation experiments. T. E. Odland, S. C. Damon, and J. L. Tennant. R. I. Sta. Bul. 224, 42 p., illus. 1930.

Fifteen years field crop work, Prescott Dry Farm, 1912–1927. S. P. Clark. Ariz. Sta. Bul. 136, p. 583–613, illus. 1931.

The Hopkinsville Experiment Field. G. Roberts, J. F. Freeman, and E. J. Kinney. Ky. Sta. Bul. 299, 30 p., illus. 1930.

A decade of crop yields from Vivian Farm. A. N. Hume. S. Dak. Sta. Bul. 253, 36 p., illus. 1930.

WEEDS

The anatomy of *Convolvulus arvensis*, wild morning-glory, or field bindweed. P. B. Kennedy and A. S. Crafts. Hilgardia [Calif. Sta.], vol. 5, no. 18, p. 591–622, illus. 1931.

St. Johnswort on range lands of California. A. W. Sampson and K. W. Parker. Calif. Sta. Bul. 503, 48 p., illus. 1930.

Puncture vine, a new pest in Idaho. H. L. Spence, jr. Idaho Sta. Circ. 60, 4 p., illus. 1930.

Lead-arsenate experiments on the germination of weed seeds. W. C. Muenscher. N. Y. Cornell Sta. Bul. 508, 10 p., illus. 1930.

North Dakota weeds. O. A. Stevens. N. Dak. Sta. Bul. 243, 58 p., illus. 1930.

Control of quack grass by tillage.—I, A progress report, Landon tillage project; II, General suggestions on control of quack grass. T. E. Stoa, V. Sturlaughson, and H. F. McColly. N. Dak. Sta. Bul. 244, 19 p., illus. 1930.

Manual of Ohio weeds. H. A. Runnels and J. H. Schaffner. Ohio Sta. Bul. 475, 166 p., illus. 1931.

HORTICULTURE

FRUITS

A study of the effect of certain fertilizer and cultural treatments upon the vigor of young Stayman apple trees. C. B. Wiggans. Ark. Sta. Bul. 254, 17 p., illus. 1930.

Apple breeding in Idaho. C. C. Vincent and L. E. Longley. Idaho Sta. Research Bul. 8, 58 p., illus. 1930.

Effect of certain hydrocarbon oils on respiration of foliage and dormant twigs of the apple. V. W. Kelley. Ill. Sta. Bul. 348, p. 369–406, illus. 1930.

Acidity changes associated with the keeping quality of apples under various storage conditions. H. H. Plagge and F. Gerhardt. Iowa Sta. Research Bul. 131, p. 341–358, illus. 1930.

A study of apple tree growth as influenced by soil conditions in the Bitter Root Valley. E. Burke, H. E. Morris, and F. M. Harrington. Mont. Sta. Bul. 241, 23 p., illus. 1931.

Some effects of defloration on fruit spur composition and fruit bud formation in the Oldenburg apple. G. F. Potter, H. R. Kraybill, S. W. Wentworth, J. T. Sullivan, and P. T. Blood. N. H. Sta. Tech. Bul. 41, 27 p., illus. 1930.

Composition and fruit bud formation in non-bearing spurs of the Baldwin apple. G. F. Potter and T. G. Phillips. N. H. Sta. Tech. Bul. 42, 43 p., illus. 1930.

The relation of hydrophilic colloids to hardiness in the apple as shown by the dye adsorption test. S. Dunn. N. H. Sta. Tech. Bul. 44, 18 p. 1930.

1931 spraying recommendations for apples. N. J. Stas. Circ. 227, 7 p. 1931.

The effect of spiral ringing on solute translocation and the structure of the regenerated tissues of the apple. L. H. MacDaniels and O. F. Curtis. N. Y. Cornell Sta. Mem. 133, 31 p., illus. 1930.

Variability and size relations in apple trees. R. C. Collison and J. D. Harlan. N. Y. State Sta. Tech. Bul. 164, 38 p. 1930.

Xenia and metaxenia in apples. B. R. Nebel. N. Y. State Sta. Tech. Bul. 170, 16 p., illus. 1930.

Bloom period and yield of apples. A 20-year average, 1910–1929. C. W. Ellenwood. Ohio Sta. Bul. 472, 21 p., illus. 1931.

Soil organic matter as a factor in the fertility of apple orchards. R. D. Anthony. Pa. Sta. Bul. 261, 35 p., illus. 1931.

Some phases of apple growing in Rhode Island. A. E. Stene. R. I. Sta. Bul. 226, 36 p., illus. 1930.

Apple thinning experiments: Cause relations of small apples; size increases of large and small apples; quarter century study of a variety orchard. M. B. Cummings, E. W. Jenkins, and R. G. Dunning. Vt. Sta. Bul. 308, 60 p., illus. 1930.

Relation of foliage to fruit size and quality in apples and pears. J. R. Magness, F. L. Overley, and W. A. Luce. Wash. Col. Sta. Bul. 249, 26 p., illus. 1931.

Topworking the apple tree. M. B. Hoffman. W. Va. Sta. Circ. 57, 31 p., illus. 1930.

Effect of certain hydrocarbon oils on the transpiration rate of some deciduous tree fruits. V. W. Kelley. Ill. Sta. Bul. 353, p. 579–600. 1930.

A study of tree stocks in relation to winter injury and its prevention. L. Childs and G. G. Brown. Oreg. Sta. Circ. 103, 15 p., illus. 1931.

Cantaloupe production in Michigan. J. B. Edmond, A. B. Strand, and F. J. McNall. Mich. Sta. Spec. Bul. 193, 51 p., illus. 1930.

The cherry industry in the Lewiston orchards, with cultural recommendations. E. C. Blodgett. Idaho Sta. Bul. 171, 19 p., illus. 1930.

Identification of mazzard and mahaleb cherry rootstocks. H. B. Tukey. N. Y. State Sta. Circ. 117, 12 p., illus. 1930.

Effects of pruning on growth and yield of cherry trees. H. L. Crane. W. Va. Sta. Bul. 240, 20 p., illus. 1931.

Some anatomical and physiological changes in citrus produced by boron deficiency. A. R. C. Haas and L. J. Klotz. Hilgardia [Calif. Sta.], vol. 5, no. 8, p. 175–196, illus. 1931.

Sap concentration and inorganic constituents of mature citrus leaves. A. R. C. Haas and F. F. Halma. Hilgardia [Calif. Sta.], vol. 5, no. 13, p. 407–424, illus. 1931.

Citrus production in the Lower Rio Grande Valley of Texas. H. P. Traub and W. H. Friend. Tex. Sta. Bul. 419, 60 p., illus. 1930.

Papaya culture in Hawaii. W. T. Pope. Hawaii Sta. Bul. 61, 40 p., illus. 1930.

The fruiting habit of the peach as influenced by pruning practices. R. E. Marshall. Mich. Sta. Tech. Bul. 116, 58 p., illus. 1931.

Comparison of one-year-old and "Junebud" peach stock for orchard planting. J. C. C. Price. Miss. Sta. Bul. 277, 19 p., illus. 1930.

Varieties of peaches. J. C. C. Price. Miss. Sta. Bul. 284, 16 p., illus. 1930.

Development and ripening of peaches as correlated with physical characteristics, chemical composition, and histological structure of the fruit flesh.—II, Histology and microchemistry. R. M. Addoms, G. T. Nightingale, and M. A. Blake. N. J. Stas. Bul. 507, 19 p., illus. 1930.

Length of the fruit development period of the Elberta and some other varieties of peaches. M. A. Blake. N. J. Stas. Bul. 511, 24 p., illus. 1930.

Physiological investigations on the resistance of peach buds to freezing temperatures. H. L. Crane. W. Va. Sta. Bul. 236, 80 p. 1930.

Residual effects of fruit thinning with the Lombard plum. J. H. Waring. Mich. Sta. Tech. Bul. 112, 36 p., illus. 1931.

1931 spray schedule for plums and cherries. N. J. Stas. Circ. 228, 4 p. 1931.

Some carbohydrate and nitrogen constituents of alternate-bearing sugar prunes associated with fruit bud formation. L. D. Davis. Hilgardia [Calif. Sta.], vol. 5, no. 6, p. 119–154, illus. 1931.

The fruiting habits and pruning of the Campbell early grape. N. L. Partridge. Mich. Sta. Tech. Bul. 106, 48 p., illus. 1930.

Fertilizers and soils in relation to Concord grapes in southwestern Michigan. N. L. Partridge and J. O. Veatch. Mich. Sta. Tech. Bul. 114, 42 p., illus. 1931.

Grape varieties. J. C. C. Price. Miss. Sta. Bul. 281, 20 p., illus. 1930.

Grape culture. A. B. Fite and A. S. Curry. N. Mex. Sta. Bul. 192, 29 p., illus. 1931.

Some cold-storage and freezing studies on the fruit of the vinifera grape. D. B. Carrick. N. Y. Cornell Sta. Mem. 131, 37 p., illus. 1930.

Open pollination vs. hand pollination of pollen-sterile grapes. O. Einset. N. Y. State Sta. Tech. Bul. 162, 14 p., illus. 1930.

Blackberry and muscadine grape culture at Hammond, Louisiana. B. Szymoniak. La. Stas. Bul. 213, 7 p. 1930.

Propagation studies with the southern blueberry. L. M. Ware. Miss. Sta. Bul. 280, 40 p., illus. 1930.

Blueberry culture. C. S. Beckwith and S. Coville. N. J. Stas. Circ. 229, 28 p., illus. 1931.

A chemical study of cranberries. F. W. Morse. Mass. Sta. Bul. 265, p. 88–102, illus. 1930.

Effect of fertilizers on cranberry land. C. S. Beckwith. N. J. Stas. Bul. 501, 16 p., illus. 1930.

Increasing the color of cranberries after removal from the vines. B. R. Fudge. N. J. Stas. Bul. 504, 24 p., illus. 1930.

Cranberry growing in New Jersey. C. S. Beckwith. N. J. Stas. Circ. 246, 40 p., illus. 1931.

Raspberry investigations. A preliminary study of the fruiting habit of the red raspberry, *Rubus strigosus*. R. V. Lott. Colo. Sta. Bul. 367, 41 p., illus. 1931.

Cultivated berries: Raspberries, blackberries, dewberries, blueberries. J. G. Woodroof. Ga. Sta. Bul 166, 32 p., illus. 1931.

A production and economic survey of the black raspberry industry of Washington County, Maryland. H. Ross and E. C. Auchter. Md. Sta. Bul. 322, p. 207–245, illus. 1930.

Black raspberry studies.—I, Some studies of expressed tissue fluids; II, Rate of water movement through excised parts of fruiting canes and current season shoots; III, Growth and yield as influenced by fertilizers. R. E. Marshall. Mich. Sta. Tech. Bul. 111, 32 p., illus. 1931.

Identification of cultivated raspberries. J. D. Winter. Minn. Sta. Tech. Bul. 66, 14 p., illus. 1930.

A study of senescence in the red raspberry cane. W. G. Brierley. Minn. Sta. Tech. Bul. 69, 36 p., illus. 1930.

Raspberries and blackberries in Ohio: Culture, J. S. Shoemaker.— Diseases, C. W. Bennett.— Insects, J. S. Houser. Ohio Sta. Bul. 454, 78 p., illus. 1930.

Strawberry varieties. J. C. C. Price. Miss. Sta. Circ. 93, 4 p., illus. 1930.

Relation of nitrogen fertilizer to the firmness and composition of strawberries. J. S. Shoemaker and E. W. Greve. Ohio Sta. Bul. 466, 20 p., illus. 1930.

Berry cultivation in western Washington. H. D. Locklin. West. Wash. Sta. Bul. 16–W, 22 p., illus. 1930.

Miscellaneous tropical and sub-tropical Florida fruits. H. Mowry and L. R. Toy. Fla. Sta. Bul. 223, 88 p., illus. 1931.

Some factors influencing the keeping quality of fruit in transit. J. W. Lloyd and H. M. Newell. Ill. Sta. Bul. 350, p. 450–484, illus. 1930.

Biennial report of the Missouri State Fruit Experiment Station, 1929–1930. F. W. Faurot. 12 p. [1930.]

VEGETABLES

Inheritance studies in *Phaseolus vulgaris*. T. M. Currence. Minn. Sta. Tech. Bul. 68, 28 p., illus. 1930.

Methods for determining the solidity of cabbage heads. O. H. Pearson. Hilgardia [Calif. Sta.], vol. 5, no. 11, p. 383–393, illus. 1931.

Fertilizer work with cabbage. L. M. Ware. Miss. Sta. Circ. 91, 4 p. 1930.

Cabbage fertilizer experiments. A. B. Fite. N. Mex. Sta. Bul. 180, 28 p., illus. 1930.

Premature heading of cauliflower as associated with the chemical composition of the plant. W. R. Robbins, G. T. Nightingale, and L. G. Schermerhorn. N. J. Stas. Bul. 509, 14 p., illus. 1931.

Celery production on the muck soils of New York. J. E. Knott. N. Y. Cornell Sta. Bul. 517, 37 p., illus. 1931.

Lettuce irrigation studies. H. C. Schwalen and M. F. Wharton. Ariz. Sta. Bul. 133, p. 459–517, illus. 1930.

Inheritance in lettuce. C. E. Durst. Ill. Sta. Bul. 356, p. 237–341, illus. [1930.]

Head lettuce in western Washington: Culture, H. D. Locklin.— Diseases, G. A. Newton. West. Wash. Sta. Bul. 19–W, 37 p., illus. 1931.

Early Grano onion culture. F. Garcia and A. B. Fite. N. Mex. Sta. Bul. 193, 15 p., illus. 1931.

Growing onions on the muck soils of New York. J. E. Knott. N. Y. Cornell Sta. Bul. 510, 34 p., illus. 1930.

Origin and nature of rogues in canning peas. E. J. Renard. Wis. Sta. Research Bul. 101, 56 p., illus. 1930.

Breeding two new varieties of greenhouse tomatoes resistant to Fusarium wilt. W. A. Huelsen and M. C. Gillis. Ill. Sta. Bul. 361, p. 408–434, illus. 1930.

Fertilizing tomatoes, sweet corn, and muskmelons in a three-year rotation. J. W. Lloyd. Ill. Sta. Bul. 364, 19 p., illus. 1931.

Growing greenhouse tomatoes. E. F. Burk and R. H. Roberts. Wis. Sta. Bul. 418, 20 p., illus. 1931.

Fertilizer experiments with truck crops.—I, Celery and lettuce on Leon fine sand; II, Tomatoes on calcareous glade soil; III, Truck crops with manganese on calcareous glade soil. J. J. Skinner and R. W. Ruprecht. Fla. Sta. Bul. 218, 65 p., illus. 1930.

Results of sweet-corn suckering experiments on Long Island. H. C. Thompson, H. S. Mills, and P. H. Wessels. N. Y. Cornell Sta. Bul. 509, 11 p., illus. 1930.

Cultivation experiments with certain vegetable crops on Long Island. H. C. Thompson, P. H. Wessels, and H. S. Mills. N. Y. Cornell Sta. Bul. 521, 14 p., illus. 1931.

The quality of packet vegetable seed on sale in New York in 1929 and 1930. M. T. Munn, O. H. Sipple, and M. E. Woodbridge. N. Y. State Sta. Bul. 587, 27 p. 1930.

The amount of manure necessary for vegetable growing, II. F. K. Crandall and T. E. Odland. R. I. Sta. Bul. 225, 31 p., illus. 1930.

ORNAMENTALS AND NUTS

Color schemes of cacti. J. M. Breazeale. Ariz. Sta. Bul. [unnumbered], 34 p., illus. 1930.

Experiments in forcing gladioli. F. F. Weinard and S. W. Decker. Ill. Sta. Bul. 357, p. 345–361. 1930.

Summer-budded versus winter-grafted roses. F. F. Weinard and S. W. Decker. Ill. Sta. Bul. 358, p. 365–373, illus. 1930.

Hardy woody plants. F. A. Waugh and C. H. Thompson. Mass. Sta. Bul. 267, p. 148–182, illus. 1930.

Experiments with hedges. F. A. Waugh. Mass. Sta. Bul. 272, 23 p., illus. 1931.

Evergreens in South Dakota. N. E. Hansen. S. Dak. Sta. Bul. 254, 33 p., illus. 1930.

Filberts. G. L. Slate. N. Y. State Sta. Bul. 588, 32 p., illus. 1930.

MISCELLANEOUS

Horticulture at the Ohio Agricultural Experiment Station. Ohio Sta. Spec. Circ. 30, 50 p., illus. 1930.

Spraying investigations. T. J. Talbert and H. G. Swartwout. Mo. Sta. Bul. 301, 16 p., illus. 1931.

FORESTRY

The tung-oil tree. W. Newell, H. Mowry, and R. M. Barnette. Fla. Sta. Bul. 221, 63 p., illus. 1930.

Marketing Illinois forest products. L. E. Sawyer. Ill. Sta. Circ. 361, 16 p., illus. 1930.

Lumber production and wood utilization in southeastern Minnesota, with special reference to the farm woodlot. L. W. Rees. Minn. Sta. Bul. 271, 28 p., illus. 1930.

Aspen availability, properties, and utilization. R. P. A. Johnson, J. Kittredge, jr., and H. Schmitz. Minn. Sta. Tech. Bul. 70, 72 p., illus. 1930.

Dry-land shelter-belt tests at the Judith Basin Branch Station. I. J. Jensen and F. M. Harrington. Mont. Sta. Bul. 233, 27 p., illus. 1930.

Dry-land shelter-belt tests at the Northern Montana Branch Station. F. M. Harrington and G. W. Morgan. Mont. Sta. Bul. 235, 16 p., illus. 1930.

Slash pine for reforestation in the Coastal Plain. W. R. Mattoon. S. C. Sta. Circ. 41, 15 p., illus. 1930.

The shade, windbreak and timber trees of South Dakota. N. E. Hansen. S. Dak. Sta. Bul. 246, 48 p., illus. 1930.

Studies in tolerance of New England forest trees.—X, The change in the environmental factors caused by thinnings in pine plantations. W. R. Adams, jr. Vt. Sta. Bul. 310, 40 p., illus. 1930.

A study of natural reproduction in Vermont forests.—I, The effect of thinning on diameter growth. G. P. Burns and W. E. White. Vt. Sta. Bul. 311, 62 p., illus. 1930.

Marketing woodland products in Virginia. J. E. Lodewick. Va. Sta. Bul. 276, 69 p., illus. 1930.

Second-growth white pine in Wisconsin: Its growth, yield, and commercial possibilities. S. R. Gevorkiantz and R. Zon. Wis. Sta. Research Bul. 98, 40 p., illus. 1930.

Logging slash and forest protection. R. Zon and R. N. Cunningham. Wis. Sta. Research Bul. 109, 36 p., illus. 1931.

Shelterbelts and fruits. A. L. Nelson. Wyo. Sta. Bul. 179, 23 p., illus. 1931.

Trees for Wyoming farmers and ranchmen. Wyo. Sta. Circ. 24, 4 p. 1931.

PLANT DISEASES

FIELD CROPS

The relative susceptibility of alfalfas to wilt and cold. G. L. Peltier and H. M. Tysdal. Nebr. Sta. Research Bul. 52, 15 p. 1930.

Bacterial wilt of alfalfa. J. S. Wiant. Wyo. Sta. Bul. 177, 20 p., illus. 1931.

"Halo spot" of beans and kudzu. B. B. Higgins. Ga. Sta. Bul. 161, 21 p., illus. 1930.

Symptomatology, transmission, infection and control of bean mosaic in Idaho. W. H. Pierce and C. W. Hungerford. Idaho Sta. Research Bul. 7, 37 p., illus. 1929.

Corn diseases in Illinois, their extent, nature and control. B. Koehler and J. R. Holbert. Ill. Sta. Bul. 354, 164 p., illus. 1930.

The control of corn diseases in Illinois. B. Koehler and J. R. Holbert. Ill. Sta. Circ. 364, 28 p., illus. 1931.

Mutation and hybridization in *Ustilago zeae*: Part I, Mutation. E. C. Stakman, J. J. Christensen, C. J. Eide, and B. Peturson. Part II, Hybridization. J. J. Christensen. Minn. Sta. Tech. Bul. 65, 108 p., illus. 1929.

Potash in relation to cotton wilt. M. N. Walker. Fla. Sta. Bul. 213, 10 p. 1930.

Cotton diseases in Florida. M. N. Walker. Fla. Sta. Bul. 214, 32 p., illus. 1930.

Cotton root-rot and its control. J. J. Taubenhaus and W. N. Ezekiel. Tex. Sta. Bul. 423, 39 p., illus. 1931.

Diseases of delphinium or larkspur. R. P. White. N. J. Stas. Circ. 234, 4 p., illus. 1931

A study of meadow-crop diseases in New York. J. G. Horsfall. N. Y. Cornell Sta. Mem. 130, 139 p., illus. 1930.

Investigations with oat varieties and diseases in the Upper Peninsula. B. R. Churchill. Mich. Sta. Spec. Bul. 213, 15 p., illus. 1931.

The organic mercury compounds for the control of scab and Rhizoctonia of potatoes. B. A. Brown. Conn. Storrs Sta. Bul. 164, p. 85–106. 1930.

Effect of seed-potato treatment on yield and rhizoctonosis in Florida from 1924 to 1929. L. O. Gratz. Fla. Sta. Bul. 220, 34 p., illus. 1930.

Potato spraying and dusting experiments in Florida, 1924 to 1929. L. O. Gratz. Fla. Sta. Bul. 222, 39 p., illus. 1930.

How to treat seed potatoes. C. W. Hungerford. Idaho Sta. Circ. 58, 8 p., illus. 1930.

Experiments with the tuber index method of controlling virus diseases of potatoes. J. E. Kotila. Mich. Sta. Tech. Bul. 117, 26 p., illus. 1931.

Research on potato-virus diseases in Montana. P. A. Young and H. E. Morris. Mont. Sta. Bul. 231, 51 p., illus. 1930.

The symptoms of spindle tuber and unmottled curly dwarf of the potato. R. W. Goss. Nebr. Sta. Research Bul. 47, 39 p., illus. 1930.

Infection experiments with spindle tuber and unmottled curly dwarf of the potato. R. W. Goss. Nebr. Sta. Research Bul. 53, 36 p. 1931.

Aphids as vectors of leafroll among sprouting potato tubers. F. C. Stewart and H. Glasgow. N. Y. State Sta. Tech. Bul. 171, 21 p., illus. 1930.

Potato diseases in Oregon and their control. M. B. McKay and T. P. Dykstra. Oreg. Sta. Circ. 96, 83 p., illus. 1930.

A tuber rot of Irish potatoes. J. A. McClintock. Tenn. Sta. Circ. 32, 4 p., illus. 1930.

Virus diseases of tobacco in Kentucky. E. M. Johnson. Ky. Sta. Bul. 306, p. 285–415, illus. 1930.

The relation of some tobacco viruses to potato degeneration. W. D. Valleau and E. M. Johnson. Ky. Sta. Bul. 309, p. 473–507, illus. 1930.

Studies on the nature of physiologic resistance to *Puccinia graminis tritici*. W. N. Ezekiel. Minn. Sta. Tech. Bul. 67, 62 p., illus. 1930.

Breeding winter wheat for resistance to stinking smut (*Tilletia levis* and *Tilletia tritici*). T. A. Kiesselbach and A. Anderson. Nebr. Sta. Research Bul. 51, 22 p., illus. 1930.

The control of bunt or stinking smut of wheat. F. D. Heald and E. F. Gaines. Wash. Col. Sta. Bul. 241, 30 p., illus. 1930.

Diseases of grain and their control. W. W. Mackie. Calif. Sta. Bul. 511, 87 p., illus. 1931.

Treatment for control of grain smuts. C. W. Hungerford. Idaho Sta. Circ. 59, 8 p., illus. 1930.

The effectiveness of Rhizobia as influenced by passage through the host plant. O. N. Allen and I. L. Bladwin. Wis. Sta. Research Bul. 106, 56 p., illus. 1931.

FRUITS AND MELONS

Canker treatment for fire blight control. J. A. McClintock and H. L. Fackler. Tenn. Sta. Circ. 36, 4 p., illus. 1931.

Apple scab spraying experiments in Tennessee. C. D. Sherbakoff and J. O. Andes. Tenn. Sta. Circ. 37, 4 p., illus. 1931.

Cantaloupe powdery mildew in the Imperial Valley. P. A. Miller and J. T. Barrett. Calif. Sta. Bul. 507, 36 p., illus. 1931.

Nutrition and composition of the Deglet Noor palm in relation to the decline disease. A. R. C. Haas and L. J. Klotz. Hilgardia [Calif. Sta.], vol. 5, no. 16, p. 511–530, illus. 1931.

Fruit spoilage diseases of figs. R. E. Smith and H. N. Hansen. Calif. Sta. Bul. 506, 84 p., illus. 1931.

Virus diseases of black raspberries. W. H. Rankin. N. Y. State Sta. Tech. Bul. 175, 24 p. 1931.

Three new wilt-resistant watermelons. I. E. Melhus, J. J. Wilson, and D. V. Layton. Iowa Sta. Circ. 125, 4 p., illus. 1931.

The treatment of lime-induced chlorosis with iron salts. J. P. Bennett. Calif. Sta. Circ. 321, 12 p., illus. 1931.

VEGETABLES

The mosaic disease of beets. L. K. Jones. Wash. Col. Sta. Bul. 250, 16 p., illus. 1931.

Black-rot of cabbage and its control. W. J. Bach and J. J. Taubenhaus. Tex. Sta. Circ. 57, 10 p., illus. 1930.

The control of celery blights. J. D. Wilson and A. G. Newhall. Ohio Sta. Bul. 461, 30 p., illus. 1930.

Cucumber disease investigations on Long Island. E. E. Clayton. N. Y. State Sta. Bul. 590, 20 p., illus. 1931.

Kale yellows in California, caused by *Fusarium conglutinans* Wollenw. J. B. Kendrick. Hilgardia [Calif. Sta.], vol. 5, no. 1, 15 p., illus. 1930.

The treatment of pea seed with chemical materials. L. K. Jones. N. Y. State Sta. Circ. 118, 3 p. 1931.

Resistance to Fusarium wilt in garden, canning and field peas. J. C. Walker. Wis. Sta. Research Bul. 107, 15 p., illus. 1931.

A pepper fruit rot new to the United States. B. B. Higgins. Ga. Sta. Bul. 162, 10 p., illus. 1930.

A chemical control of sweet potato scurf. R. F. Poole. N. C. Sta. Tech. Bul. 38, 52 p., illus. 1930.

Combating damping-off of tomatoes by seed treatment. J. G. Horsfall. N. Y. State Sta. Bul. 586, 22 p., illus. 1930.

Damping-off of tomatoes combated by seed treatment with copper compounds. J. G. Horsfall. N. Y. State Sta. Circ. 120, 4 p., illus. 1931.

NUTS

Chestnut blight in Michigan. D. V. Baxter and F. C. Strong. Mich. Sta. Circ. 135, 18 p., illus. 1931.

Save black walnut from canker. C. R. Orton and J. M. Ashcroft. W. Va. Sta. Circ. 58, 4 p., illus. 1930.

TREES, ORNAMENTALS, AND MISCELLANEOUS

Diseases of China asters. R. P. White. N. J. Stas. Circ. 232, 4 p., illus. 1931.

Diseases of boxwood. R. P. White. N. J. Stas. Circ. 230, 2 p., illus. 1931.

Diseases of carnations. R. P. White. N. J. Stas. Circ. 231, 4 p., illus. 1931.

Diseases of chrysanthemums. R. P. White. N. J. Stas. Circ. 233, 2 p. 1931.

Winter injury of evergreens. R. P. White. N. J. Stas. Circ. 245, 2 p., illus. 1931.

Diseases of gladiolus. R. P. White. N. J. Stas. Circ. 235, 7 p., illus 1931.

Diseases of hollyhocks. R. P. White. N. J. Stas. Circ. 236, 2 p., illus. 1931.

Diseases of iris. R. P. White. N. J. Stas. Circ. 237, 4 p., illus. 1931.

Diseases of laurel. R. P. White. N. J. Stas. Circ. 238, 2 p., illus. 1931.

A maple leaf disease caused by *Cristulariella depraedans*. P. R. Bowen. Conn. State Sta. Bul. 316, p. 621–647, illus. 1930.

Diseases of peonies. R. P. White. N. J. Stas. Circ. 239, 7 p., illus. 1931.

Timber-rot in the pepper tree, *Schinus molle*. J. G. Brown. Ariz. Sta. Bul. 132, p. 443–454, illus. 1930.

Diseases of perennial and annual phlox. R. P. White. N. J. Stas. Circ. 240, 3 p., illus. 1931.

Diseases of roses. R. P. White. N. J. Stas. Circ. 241, 11 p., illus. 1931.

Diseases of snapdragons. R. P. White. N. J. Stas. Circ. 242, 4 p., illus. 1931.

Diseases of sweet peas. R. P. White. N. J. Stas. Circ. 243, 4 p., illus. 1931.

Diseases of tulips. R. P. White. N. J. Stas. Circ. 244, 4 p., illus. 1931.

Diseases of ornamental plants. R. P. White. N. J. Stas. Circ. 226, 98 p., illus. 1931.

Verticillium hadromycosis. B. A. Rudolph. Hilgardia [Calif. Sta.], vol. 5, no. 9, p. 197–360, illus. 1931.

FUNGICIDES

Studies on fungicides: I, Concepts and terminology. H. H. Whetzel and S. E. A. McCallan. II, Testing protective fungicides in the laboratory. III, The solvent action of spore excretions and other agencies on protective copper fungicides. S. E. A. McCallan. N. Y. Cornell Sta. Mem. 128, 79 p., illus. 1930.

The waste sulphite material of paper mills as an adjuvant to certain spray materials. R. H. Hurt. Va. Sta. Bul. 277, 10 p. 1931.

ENTOMOLOGY AND ZOOLOGY

INSECTS AFFECTING FIELD CROPS

The alfalfa-seed chalcis-fly in Utah, 1926–29, inclusive. C. J. Sorenson. Utah Sta. Bul. 218, 36 p., illus. 1930.

Drouth checks corn-borer advance in 1930. W. P. Flint, W. P. Hayes, G. H. Dungan, and A. L. Young. Ill. Sta. Circ. 367, 8 p., illus. 1931.

European corn borer control. Progress report, 1931. H. J. Reed. Ind. Sta. Circ. 178, 12 p., illus. 1931.

Investigations of corn borer control at Monroe, Michigan. A. R. Marston and C. B. Dibble. Mich. Sta. Spec. Bul. 204, 47 p., illus. 1930.

The sources of American corn insects. C. R. Neiswander. Ohio Sta. Bul. 473, 98 p., illus. 1931.

Frankliniella fusca Hinds (thrips) on seedling cotton. C. O. Eddy and E. M. Livingstone. S. C. Sta. Bul. 271, 23 p., illus. 1931.

Potato flea-beetles. H. H. Jewett. Ky. Sta. Bul. 297, p. 281–301, illus. 1929.

Spraying and dusting experiments with potatoes on Long Island. H. C. Huckett. N. Y. State Sta. Bul. 592, 38 p., illus. 1931.

Aphids on potato sprouts. F. C. Stewart and H. Glasgow. N. Y. State Sta. Circ. 119, 6 p., illus. 1931.

Damage by the rice water weevil proved negligible. J. W. Ingram and W. A. Douglas. La. Stas. Bul. 214, 8 p. 1930.

The rice weevil and associated insects in relation to shuck lengths and corn varieties. O. L. Cartwright. S. C. Sta. Bul. 266, 28 p., illus. 1930.

New protection against stored-grain insects. W. P. Flint and C. O. Mohr. Ill. Sta. Bul. 359, p. 376–388, illus. 1930.

A review of research on the control of wireworms. C. A. Thomas. Pa. Sta. Bul. 259, 52 p., illus. 1930.

INSECTS AFFECTING VEGETABLES AND FRUITS

Apple aphids in Ohio. **C. R. Cutright.** Ohio Sta. Bul. 464, 59 p., illus. 1930.

The Mexican bean beetle. H. L. Sweetman. Wyo. Sta. Bul. 176, 23 p., illus. 1931.

The biological control of mealybugs attacking citrus. H. S. Smith and H. M. Armitage. Calif. Sta. Bul. 509, 74 p., illus. 1931.

Codling moth and peach worm investigations. Progress report, 1931. H. J. Reed. Ind. Sta. Circ. 179, 8 p., illus. 1931.

Preparation and use of chemically treated bands for codling moth control. G. E. Marshall. Ind. Sta. Circ. 180, 4 p., illus. 1931.

Some studies on the larval parasites of the oriental peach moth (*Laspeyresia molesta* Busck). B. F. Driggers. N. J. Stas. Bul. 510, 19 p., illus. 1930.
Oriental fruit moth investigations in Ohio, I. L. A. Stearns and R. B. Neiswander. Ohio Sta. Bul. 457, 36 p., illus. 1930.
Life history of the oriental fruit moth in Virginia. L. Cagle. Va. Sta. Bul. 270, 48 p., illus. 1930.
Pea-weevil control in the Willamette Valley. A. O. Larson. Oreg. Sta. Circ. 99, 12 p., illus. 1931.
The snowy tree cricket and other insects injurious to raspberries. L. M. Smith. Calif. Sta. Bul. 505, 38 p., illus. 1930.
The squash vine borer, *Melittia satyriniformis* Hübner. R. B. Friend. Conn. State Sta. Bul. 328, p. 587–608, illus. 1931.
Truck crop investigations: Further studies of truck crop aphids. G. E. Gould. Va. Truck Sta. Bul. 71, p. 811–835, illus. 1930.

MISCELLANEOUS

Preliminary studies on Arkansas horse-flies. H. H. Schwardt and D. G. Hall. Ark. Sta. Bul. 256, 27 p., illus. 1930.
Termites and termite damage, with preliminary recommendations for prevention and control. S. F. Light, M. Randall, and F. G. White. Calif. Sta. Circ. 318, 64 p., illus. 1930.
Mass production of egg parasites of the genus Trichogramma. Hilgardia [Calif. Sta.], vol. 4, no. 16, p. 465–501, illus. 1930.
The temperature relationships of *Trichogramma minutum* as a basis for racial segregaion. S. E. Flanders. Hilgardia [Calif. Sta.], vol. 5, no. 12, p. 395–406, illus. 1931.
Connecticut State Entomologist, thirtieth report, 1930. W. E. Britton. Conn. State Sta. Bul. 327, p. 451–582, illus. 1931.
Montana insect pests for 1929 and 1930, the twenty-third report of the State Entomologist of Montana. R. A. Cooley. Mont. Sta. Bul. 238, 23 p., illus. 1930.
Some shade-tree pests and their control. G. W. Herrick. N. Y. Cornell Sta. Bul. 515, 26 p., illus. 1931.
The Eriophyidae of New York.—II, The maple mites. H. E. Hodgkiss. N. Y. State Sta. Tech. Bul. 163, 45 p., illus. 1930.
Insect pests of trees and gardens. J. A. Munro and H. W. Riddle. N. Dak. Sta. Circ. 42, 56 p., illus. 1930.
Protecting South Carolina from crop pests and plant diseases. J. A. Berly. S. C. Sta. Circ. 43, 32 p., illus. 1930.

INSECTICIDES

Studies in contact insecticides.—III, A numerical rating for the contact performance of a spray material. W. C. O'Kane, W. A. Westgate, L. C. Glover, and P. R. Lowry. N. H. Sta. Tech. Bul. 46, 8 p., illus. 1931.
Oil sprays for dormant use. A. Spuler, F. L. Overley, and E. L. Green. Wash. Col. Sta. Bul. 247, 27 p., illus. 1931.

BEEKEEPING

The metabolism of the honeybee colony during winter. C. L. Corkins. Wyo. Sta. Bul. 175, 54 p., illus. 1930.

ZOOLOGY

Birds of Arkansas. W. J. Baerg. Ark. Sta. Bul. 258, 197 p., illus. 1931.
Common injurious mammals of Minnesota. M. S. Johnson. Minn. Sta. Bul. 259, 67 p., illus. 1930.
The food habits of the ring-necked pheasant in central Nebraska. M. H. Swenk. Nebr. Sta. Research Bul. 50, 33 p., illus. 1930.
The swallows, goatsuckers and swifts of New Jersey. L. A. Hausman. N. J. Stas. Bul. 520, 32 p., illus. 1931.
Trapping the oyster drill. J. R. Nelson. N. J. Stas. Bul. 523, 12 p., illus. 1931.
Making use of our birds. O. A. Stevens. N. Dak. Sta. Bul. 241, 40 p., illus. 1930.
Snakes of Utah. H. J. Pack. (Compiled by G. F. Knowlton.) Utah Sta. Bul. 221, 32 p., illus. 1930.

FOODS AND HUMAN NUTRITION

FOOD TECHNOLOGY

Pickling green olives. W. V. Cruess. Calif. Sta. Bul. 498, 42 p., illus. 1930.
Dehydration of grapes. P. F. Nichols and A. W. Christie. Calif. Sta. Bul. 500, 31 p., illus. 1930.
The swelling of canned prunes. E. M. Mrak and P. H. Richert. Calif. Sta. Bul. 508, 24 p., illus. 1931.
Preservation of fruits and vegetables by freezing storage. M. A. Joslyn. Calif. Sta. Circ. 320, 35 p., illus. 1930.
Fruit jellies.—VII. The role of pectin: 3, Effect of temperature upon the extraction of pectin. P. B. Myers and G. L. Baker. Del. Sta. Bul. 168, 46 p., illus. 1931.
Preserving fruits by freezing.—I, Peaches. J. G. Woodroof. Ga. Sta. Bul. 163, 46 p., illus. 1930.
Preserving fruits by freezing.—II, Figs. J. G. Woodroof and J. E. Bailey. Ga. Sta. Bul. 164, 11 p., illus. 1930.
Fruit freezing conference, Georgia Experiment Station and co-operators. Compiled by J. G. Woodroof. Ga. Sta. Circ. 89, 15 p. 1930.
Commercially prepared infant foods. G. J. and A. M. Hucker. N. Y. State Sta. Bul. 584, 13 p., illus. 1930.
A new method for enzymic clarification of unfermented apple juice. Z. I. Kertesz. N. Y. State Sta. Bul. 589, 10 p., illus. 1930.
Floral changes in the fermentation of sauerkraut. C. S. Pederson. N. Y. State Sta. Tech. Bul. 168, 37 p., illus. 1930.
The effect of pure culture inoculation on the quality and chemical composition of sauerkraut. C. S. Pederson. N. Y. State Sta. Tech. Bul. 169, 29 p., illus. 1930.
Bleaching and dyeing Royal Ann cherries for maraschino or fruit salad use. D. E. Bullis and E. H. Wiegand. Oreg. Sta. Bul. 275, 29 p., illus. 1931.

FOOD PREPARATION

Baking flour mixtures at high altitudes. M. W. Peterson. Colo. Sta. Bul. 365, 180 p., illus. 1930.
Baking quick breads and cakes at high altitudes. A guide to housewives. M. W. Peterson. Colo. Sta. Bul. 366, 48 p., illus. 1930.
Home canning of meat under conditions in Louisiana. G. Sunderlin. La. Stas. Bul. 220, 8 p. 1931.
How certain methods of cooking affect the quality and palatability of beef. J. A. Cline, E. A. Trowbridge, M. T. Foster, and H. E. Fry. Mo. Sta. Bul. 293, 40 p., illus. 1930.
Veal in variety. E. Latzke and C. Leeby. N. Dak. Sta. Bul. 239, 32 p., illus. 1930.
Standardizing methods of roasting beef in experimental cookery. E. Latzke. N. Dak. Sta. Bul. 242, 18 p., illus. 1930.

Baking vegetables electrically. V. W. Swartz. Wash. Col. Sta. Bul. 251, 19 p., illus. 1931.

VITAMIN CONTENT

Vitamin-B and vitamin-G content of cereals. R. A. Hetler, C. R. Meyer, and D. Hussemann. Ill. Sta. Bul. 369, p. 167–211, illus. 1931.

The vitamin A content of the milk of Holstein, Ayrshire, Jersey, and Guernsey cows. H. P. Davis and I. L. Hathaway. Nebr. Sta. Research Bul. 54, 14 p. 1931.

Variations in vitamin A and in chemical composition of corn. G. S. Fraps. Tex. Sta. Bul. 422, 46 p. 1931.

NUTRITION

The cause of mottled enamel, a defect of human teeth. M. C. Smith, E. M. Lantz, and H. V. Smith. Ariz. Sta. Tech. Bul. 32, p. 251–282, illus. 1931.

Dietary requirements for fertility and lactation.—I, The role of fat soluble vitamins in fertility and lactation. B. Sure. Ark. Sta. Bul. 250, 67 p., illus. 1930.

Dietary requirements for fertility and lactation.—II, The role of vitamin B in lactation and vitamin requirements of nursing young. B. Sure. Ark. Sta. Bul. 251, 62 p., illus. 1930.

Dietary requirements for fertility and lactation.—III, Pathological changes in nursing young of the albino rat suffering from vitamin B deficiency, and the role of vitamin B in infant nutrition. B. Sure. Ark. Sta. Bul. 252, 50 p., illus. 1930.

Basal metabolism of young women. H. McKay. Ohio Sta. Bul. 465, 37 p., illus. 1930.

A nutritional study of the white school children in five representative counties of Florida. C. F. Ahmann, O. D. Abbott, and G. Westover. Fla. Sta. Bul. 216, 50 p., illus. 1930.

The diet of school children in relation to their health. M. E. Frayser and A. M. Moser. S. C. Sta. Bul. 268, 64 p., illus. 1930.

RURAL HOME MANAGEMENT

An economic study of food consumed by farm and village families in central New York. F. M. Williams and J. E. Lockwood. N. Y. Cornell Sta. Bul. 502, 52 p., illus. 1930.

Food consumption of fifty Vermont farm householders. M. Muse and I. Gullum. Vt. Sta. Bul. 327, 30 p., illus. 1931.

The use of time by South Dakota farm homemakers. G. E. Wasson. S. Dak. Sta. Bul. 247, 29 p., illus. 1930.

Fuels used for cooking purposes in Indiana rural homes. M. Rapp. Ind. Sta. Bul. 339, 32 p., illus. 1930.

A study of kerosene cook stoves. E. B. Snyder. Nebr. Sta. Research Bul. 48, 44 p., illus. 1930.

Selection and management of kerosene cook stoves. E. B. Snyder. Nebr. Sta. Circ. 41, 14 p., illus. 1930.

The efficiency of the home laundry plant. E. H. Roberts. Wash. Col. Sta. Bul. 248. 39 p., illus. 1931.

The cost of clothing the Nebraska farm family. J. O. Rankin. Nebr. Sta. Bul. 248, 22 p., illus. 1930.

The relation between the economic status of the Oklahoma farm family and the farm woman's standards of management with respect to clothing. G. Fernandes. Okla. Sta. Bul. 197, 16 p. 1930.

A study of women's coats. A. O. Halgrim. S. Dak. Sta. Bul. 248, 30 p., illus. 1930.

ANIMAL PRODUCTION

ANIMAL NUTRITION AND FEEDING STUFFS

The feeding value of the grain sorghums, hegari and yellow milo compared with yellow corn. M. C. Smith. Ariz. Sta. Timely Hints for Farmers 161, 9 p., illus. 1930.

Some effects of varying calcium and phosphorus intake on the estrus cycle and reproduction in the rat. H. R. Guilbert and G. H. Hart. Hilgardia [Calif. Sta.], vol. 5, no. 5, p. 101–118, illus. 1930.

The digestibility of bur clover as affected by exposure to sunlight and rain. H. R. Guilbert and S. W. Mead.—The effect of leaching on the nutritive value of forage plants. H. R. Guilbert, S. W. Mead, and H. C. Jackson. Hilgardia [Calif. Sta.], vol. 6, no. 1, 26 p. 1931.

Utilizing the soybean crop in livestock feeding, a statement of its value for dairy cattle, beef cattle, sheep, horses, swine, poultry. H. P. Rusk et al. Ill. Sta. Circ. 369, 44 p., illus. 1931.

Growth and development, with special reference to domestic animals.—XIV, (a) Measurements of growing Holstein and Jersey cattle on Missouri farms. A. C. Ragsdale and M. J. Regan.—(b) Prediction charts for growth of cattle. S. Brody and A. C. Ragsdale. Mo. Sta. Research Bul. 142, 30 p., illus. 1930.

Growth and development, with special reference to domestic animals.—XV, Energy and nitrogen metabolism during the first year of postnatal life. S. Brody et al. Mo. Sta. Research Bul. 143, 208 p., illus. 1930.

Production and feeding of silage. L. J. Stadler. M. M. Jones. C. W. Turner, and P. M. Bernard. Mo. Sta. Bul. 287, 19 p., illus. 1930.

Winter rations for the farm flock in eastern Oregon. R. Withycombe, F. M. Edwards, and E. L. Potter. Oreg. Sta. Circ. 101, 14 p., illus. 1931.

Value of grinding grains and roughages for livestock. J. W. Wilson, R. L. Patty, T. Wright, and T. M. Olson. S. Dak. Sta. Bul. 252, 56 p. 1930.

Digestibility by sheep of the constituents of the nitrogen-free extract of feeds. G. S. Fraps. Tex. Sta. Bul. 418, 15 p. 1930.

The estimation of salt and molasses in mixed feeds. G. S. Fraps. Tex. Sta. Bul. 425, 12 p. 1931.

Chopping hay for livestock and steaming or pre-digesting feeds. G. Bohstedt et al. Wis. Sta. Research Bul. 102, 32 p., illus. 1930.

BEEF CATTLE

Rations for fattening range calves in Arizona. E. B. Stanley. Ariz. Sta. Bul. 137, p. 615–638, illus. 1931.

Beef producing qualities of purebred Aberdeen-Angus cattle compared with Arkansas native cattle. H. E. Dvorachek and A. T. Semple. Ark. Sta. Bul. 247, 19 p., illus. 1931.

Effects of sex, length of feeding period, and a ration of ear-corn silage on the quality of baby beef. S. Bull, F. C. Olson, and J. H. Longwell. Ill. Sta. Bul. 355, p. 165–233, illus. 1930.

Effects of sex, length of feeding period, and a ration of ear-corn silage on the quality of baby beef. S. Bull, F. C. Olson, and J. H. Longwell. Ill. Sta. Abstract of Bul. 355, 19 p., illus. 1930.

Roughages for fattening two-year-old steers. J. M. Evvard et al. Iowa Sta. Bul. 253 (abridged), 8 p. 1928.

Relative efficiency of calves, yearlings and two-year-old steers for the producer. C. C. Culbertson, J. M. Evvard, and W. E. Hammond. Iowa Sta. Bul. 271, p. 239–299, illus. 1930.

Shall I feed calves, yearlings or two-year-olds? C. C. Culbertson, J. M. Evvard, and W. E. Hammond. Iowa Sta. Bul. 271 (abridged), 8 p., illus. 1930.

Influence of the animal's age upon the quality and palatability of beef.—Part. I, Carcass yields and quality of meat cuts. M. D. Helser.—Part II, The roast beef, preparation, quality and palatability. P. M. Nelson, B. Lowe, and M. D. Helser. Iowa Sta. Bul. 272, p. 302–323, illus. 1930.

The inheritance of color and horns in blue-gray cattle, II. J. M. Evvard, P. S. Shearer, E. W. Lindstrom, and A. D. B. Smith. Iowa Sta. Research Bul. 133, 17 p., illus. 1930.

Sweet clover hay for beef cattle, fattening baby beeves and two-year-old steers. O. M. Kiser and W. H. Peters. Minn. Sta. Bul. 261, 28 p. 1930.

Grinding shelled corn, barley, and alfalfa hay; feeding cane molasses to fattening cattle; peat-land hay as roughage for cattle. W. H. Peters. Minn. Sta. Bul. 274, 27 p., illus. 1931.

Comparison of roughages for finishing steers. D. S. Buchanan. Miss. Sta. Bul. 278, 11 p., illus. 1930.

Sex and age as factors in cattle feeding. H. J. Gramlich and R. R. Thalman. Nebr. Sta. Bul. 252, 55 p., illus. 1930.

Supplemental feeding of range cattle. J. L. Lantow. N. Mex. Sta. Bul. 185, 32 p., illus. 1930.

Investigations in the feeding of cottonseed meal to cattle. J. O. Halverson and F. W. Sherwood. N. C. Sta. Tech. Bul. 39, 158 p., illus. 1930.

Feeding low-grade wheat to cattle and sheep. J. H. Shepperd and F. W. Christensen. N. Dak. Sta. Circ. 44, 10 p. 1930.

Molasses in ration for fattening calves. P. Gerlaugh. Ohio Sta. Bul. 463, 13 p. 1930.

Deferred breeding of beef cows. R. Withycombe, E. L. Potter, and F. M. Edwards. Oreg. Sta. Bul. 271, 18 p., illus. 1930.

Fattening calves and yearlings. E. L. Potter, R. Withycombe, and F. M. Edwards. Oreg. Sta. Bul. 276, 18 p., illus. 1931.

A comparison of normal corn silage with grainless corn silage for finishing beef cattle. M. Jacob and H. R. Duncan. Tenn. Sta. Bul. 144, 22 p., illus. 1930.

DAIRY CATTLE

Corn silage feeding investigations: Seventh paper, Variations in hay consumption of dairy cattle with corn silages of different dry matter content. G. C. White, R. E. Johnson, and R. G. Connelly. Conn. Storrs Sta. Bul. 167, p. 191–203. 1930.

Corn silage feeding investigations: Eighth paper, Optimum amount of silage in the dairy ration for economical production. G. C. White and A. D. Pratt. Conn. Storrs Sta. Bul. 169, p. 235–251. 1930.

Feeding the dairy herd. W. B. Nevens. Ill. Sta. Circ. 372, 52 p., illus. 1931.

Supplements to a milk diet for dairy calves. C. Y. Cannon. Iowa Sta. Research Bul. 136, p. 65–103, illus. 1931.

Feeding dairy cows. R. H. Lush. La. Stas. Circ. 1, 60 p., illus. 1930.

Selection and care of the dairy sire. R. H. Lush. La. Stas. Circ. 5, 32 p., illus. 1931.

The anatomy of the mammary gland of cattle.—I, Embryonic development. C. W. Turner. Mo. Sta. Research Bul. 140, 34 p., illus. 1930.

Growth and development, with special reference to domestic animals.—XIII, The influence of certain geographical and historical conditions on the physical development of Lombardy, Brown-Swiss, Brittany, Dairy Shorthorn, Ayrshire, and Beef Shorthorn breeds of cattle. J. Ashton. Mo. Sta. Research Bul. 141, 67 p., illus. 1930.

The mode of inheritance of yearly butterfat production, an analysis of the progeny performance of Holstein-Friesian sires; genealogy tables of Holstein-Friesian sires. W. Gifford. Mo. Sta. Research Bul. 144, 62 p., illus. 1930.

The effect of the estrus producing hormone on the growth of the mammary gland. C. W. Turner and A. H. Frank. Mo. Sta. Research Bul. 145, 56 p., illus. 1930.

The inheritance of body weight in relation to milk secretion. C. W. Turner. Mo. Sta. Research Bul. 147, 42 p., illus. 1930.

A study of the estrus producing hormone in the urine of cattle during pregnancy. C. W. Turner, A. H. Frank, C. H. Lomas, and C. W. Nibler. Mo. Sta. Research Bul. 150, 43 p., illus. 1930.

Feeding experiments with dairy cows. F. B. Headley. Nev. Sta. Bul. 119, 21 p., illus. 1930.

Dicalcium phosphate as a mineral supplement for dairy cows. C. C. Hayden, C. F. Monroe, and C. H. Crawford. Ohio Sta. Bul. 455, 26 p., illus. 1930.

Dairying at the Ohio Agricultural Experiment Station, Wooster, Ohio. Ohio Sta. Spec. Circ. 29, 40 p., illus. 1930.

Irrigated pastures for dairy cattle. I. R. Jones and P. M. Brandt. Oreg. Sta. Bul. 264, 30 p., illus. 1930.

The comparative value of kale and corn silage for milk production. I. R. Jones and P. M. Brandt. Oreg. Sta. Bul. 272, 34 p., illus. 1930.

Care and management of the dairy bull. J. P. LaMaster. S. C. Sta. Bul. 272, 12 p., illus. 1931.

Raising dairy calves. G. B. Caine. Utah Sta. Circ. 87, 12 p., illus. 1930.

Feeding Hevea rubber seed meal for milk production. W. B. Ellett, C. W. Holdaway, J. F. Eheart, and L. D. Lasting. Va. Sta. Tech. Bul. 41, 12 p. 1930.

Feeding dairy cows. H. O. Henderson and J. V. Hopkins. W. Va. Sta. Circ. 56, 20 p., illus. 1930.

Cut the cost of feeding cows. E. B. Hart and G. C. Humphrey. Wis. Sta. Bul. 417, 20 p., illus. 1930.

SHEEP AND GOATS

Lamb feeding investigation. R. F. Johnson, E. F. Rinehart, and C. W. Hickman. Idaho Sta. Bul. 176, 10 p. 1931.

Sheep feeding: Fattening western lambs, 1928. C. Harper. Ind. Sta. Bul. 333, 16 p., illus. 1929.

Sheep feeding: Fattening western lambs (type test), 1925–26, 1926–27, 1927–28, 1928–29. C. Harper. Ind. Sta. Bul. 343, 16 p., illus. 1930.

Lamb production.—I, Producing native lambs; the value of pasture, 1927–1928–1929. C. Harper. Ind. Sta. Bul. 344, 28 p., illus. 1930.

Fattening lambs. P. S. Jordan and W. H. Peters. Minn. Sta. Bul. 272, 26 p., illus. 1930.

Relation of size of grade fine wool ewes to their production. W. E. Joseph. Mont. Sta. Bul. 242, 15 p., illus. 1931.

Raising early lambs from aged western ewes. A. D. Weber. Nebr. Sta. Bul. 250, 31 p., illus. 1930.

Corn, wheat, and rye for fattening lambs. M. L. Baker. Nebr. Sta. Bul. 256, 7 p., illus. 1931.

Wheat for fattening lambs. A. D. Weber and W. J. Loeffel. Nebr. Sta. Bul. 257, 16 p., illus. 1931.
The energy metabolism of sheep. E. G. Ritzman and F. G. Benedict. N. H. Sta. Tech. Bul. 43, 23 p., illus. 1930.
Corn, barley and grain sorghums for fattening lambs. A. E. Darlow. Okla. Sta. Bul. 196, 8 p. 1930.
Producing early lambs. W. L. Henning, P. T. Ziegler, and P. C. MacKenzie. Pa. Sta. Bul. 255, 19 p., illus. 1930.
Wool studies with Rambouillet sheep, No. II. F. S. Hultz and L. J. Paschal. Wyo. Sta. Bul. 174, 31 p. 1930.
Studies with Hampshire sheep, No. 1. F. S. Hultz and M. A. Alexander. Wyo. Sta. Bul. 178, 30 p., illus. 1931.

SWINE

Oats with vetch or Austrian peas as grazing crops for fattening hogs. J. C. Grimes, W. E. Sewell, and W. C. Taylor. Ala. Sta. Bul. 233, 14 p. 1930.
Grading up hogs by the use of purebred sires. J. C. Grimes, W. E. Sewell, and W. C. Taylor. Ala. Sta. Bul. 234, 12 p. 1930.
Wheat and wheat by-products in swine production. J. E. Nordby. Idaho Sta. Circ. 55, 4 p. 1929.
Alfalfa hay and alfalfa leaves as supplements in dry lot rations for finishing fall pigs. J. E. Nordby. Idaho Sta. Circ. 56, 3 p., illus. 1929.
Wheat supplemented with tankage in limited and full grain rations on alfalfa forage. J. E. Nordby. Idaho Sta. Circ. 57, 2 p. 1929.
Effect of soybeans and soybean oil meal on quality of pork. S. Bull, W. E. Carroll, F. C. Olson, G. E. Hunt, and J. H. Longwell. Ill. Sta. Bul. 366, p. 33–80, illus. 1931.
The two-litter hog system on Indiana farms. G. E. Young. Ind. Sta. Bul. 338, 35 p., illus. 1930.
The influence of the growth and fattening processes on the quantity and quality of meat yielded by swine. E. L. Scott. Ind. Sta. Bul. 340, 105 p., illus. 1930.
Soybeans as a substitute for tankage in fattening spring pigs on legume pasture. C. M. Vestal. Ind. Sta. Bul. 341, 14 p., illus. 1930.
Soft ear corn silage for swine. J. M. Evvard, C. C. Culbertson, Q. W. Wallace, and E. J. Maynard. Iowa Sta. Bul. 273, p. 327–369, illus. 1930.
Feeding ensiled versus dried soft ear corn to swine. J. M. Evvard, C. C. Culbertson, Q. W. Wallace, and E. J. Maynard. Iowa Sta. Bul. 273 (abridged), 8 p., illus. 1930.
Swine performance record litter comparisons. C. C. Culbertson, J. M. Evvard, H. H. Kildee, and M. D. Helser. Iowa Sta. Bul. 277, p. 86–116, illus. 1931.
Studies in swine feeding, Parts I, II, III. W. E. J. Edwards. Mich. Sta. Spec. Bul. 199, 36 p., illus. 1930.
Grazing and feeding trials with corn and soybeans for pork production. P. G. Bedenbaugh. Miss. Sta. Bul. 283, 8 p., illus. 1930.
Pasture crops for spring pigs, their value and use. W. E. Joseph. Mont. Sta. Bul. 236, 31 p., illus. 1930.
Pork production at the North Platte Substation. W. P. Snyder. Nebr. Sta. Bul. 243, 20 p. 1930.
Barley as hog feed. W. J. Loeffel. Nebr. Sta. Bul. 251, 20 p., illus. 1930.
A manual for hog raisers. W. J. Loeffel. Nebr. Sta. Circ. 40, 61 p., illus. 1930.
Soybeans and soybean oilmeal for pigs. W. L. Robison. Ohio Sta. Bul. 452, 42 p., illus. 1930.
Swine feeding experiments. W. L. Robison. Ohio Sta. Spec. Circ. 32, 15 p. [1931.]
Fattening pigs for market. A. W. Oliver and E. L. Potter. Oreg. Sta. Bul. 269, 22 p., illus. 1930.
Swine production in Utah. H. H. Smith. Utah Sta. Circ. 90, 27 p., illus. 1930.
The Wisconsin self-feeder for hogs. G. Bohstedt. Wis. Sta. Bul. 419, 24 p., illus. 1931.

POULTRY

A biometrical study of the mortality of single comb White Leghorn chicks. E. C. Voorhies and G. A. Read. Hilgardia [Calif. Sta.], vol. 5, no. 17, p. 531–590, illus. 1931.
Some effects of pimiento pepper on poultry. W. L. Brown. Ga. Sta. Bul. 160, 11 p., illus. 1930.
The management of baby chicks in confinement. C. M. Bice. Hawaii Sta. Circ. 1, 15 p., illus. 1931.
A technical study of the growth of White Leghorn chickens. H. H. Mitchell, L. E. Card, and T. S. Hamilton. Ill. Sta. Bul. 367, p. 83–139, illus. 1931.
Rearing turkeys in confinement. H. H. Alp. Ill. Sta. Circ. 357, 4 p., illus. 1930.
Factors influencing egg production.—II, The influence of the date of first egg upon maturity and egg production. C. W. Knox. Iowa Sta. Research Bul. 128, p. 237–252. 1930.
Crossbred poultry. D. C. Warren. Kans. Sta. Bul. 252, 54 p., illus. 1930.
The effect of vitamin D supplements on laying hens. J. H. Martin, S. E. Erikson, and W. M. Insko, jr. Ky. Sta. Bul. 304, p. 187–218, illus. 1930.
Duration of annual molt in relation to egg production. F. A. Hays and R. Sanborn. Mass. Sta. Bul. 264, p. 71–85. 1930.
Mississippi egg storage test. G. R. Sipe. Miss. Sta. Circ. 94, 6 p. 1930.
The influence of various protein concentrates on egg production. H. L. Kempster. Mo. Sta. Bul. 288, 20 p. 1930.
Growth and development with special reference to domestic animals.—XVI, The influence of temperature and breeding upon the rate of growth of chick embryos. E. W. Henderson. Mo. Sta. Research Bul. 149, 47 p., illus. 1930.
Hopper-feeding grain. T. B. Charles and H. O. Stuart. N. H. Sta. Circ. 33, 7 p. 1930.
Care and management of baby chicks. W. C. Thompson. N. J. Stas. Circ. 247, 32 p., illus. 1931.
Poultry farm routine. J. C. Taylor. N. J. Stas. Hints to Poultrymen, vol. 18, no. 9. 4 p. 1930.
A new basis of selection. W. C. Thompson. N. J. Stas. Hints to Poultrymen, vol. 18, no. 11, 4 p. 1930.
Broiler production. C. S. Platt. N. J. Stas. Hints to Poultrymen, vol. 19, no. 1, 4 p., illus. 1930.
New Jersey egg-laying contests, 1929–30. J. W. Goodman. N. J. Stas. Hints to Poultrymen, vol. 19, no. 2, 4 p. 1930.
The operation of battery brooders. C. S. Platt. N. J. Stas. Hints to Poultrymen, vol. 19, no. 3, 4 p., illus. 1930.
Flock improvement through selection of hatching eggs. W. C. Thompson. N. J. Stas. Hints to Poultrymen, vol. 19, no. 4, 4 p., illus. 1931.
Grading eggs on the farm. A. E. Jones and C. S. Platt. N. J. Stas. Hints to Poultrymen, vol. 19, no. 7, 4 p., illus. 1931.
The relative value of cottonseed meal and tankage for egg production. L. N. Berry. N. Mex. Sta. Bul. 183, 19 p., illus. 1930.

The molting factor in judging fowls for egg production. D. R. Marble. N. Y. Cornell Sta. Bul. 503, 42 p., illus. 1930.

Biochemistry and biophysics of the developing hen's egg.—I, Influence of humidity. A. L. Romanoff. N. Y. Cornell Sta. Mem. 132, 27 p., illus. 1930.

All-night light for layers. D. C. Kennard and V. D. Chamberlin. Ohio Sta. Bul. 476, 22 p., illus. 1931.

Poultry feeding experiments. C. L. Morgan. S. C. Sta. Bul. 273, 16 p., illus. 1931.

Rules and regulations for the seventh Utah intermountain egg-laying contest. B. Alder. Utah Sta. Circ. 89, 4 p., illus. 1930.

DAIRYING

Corrosion of metals by milk and its relation to the oxidized flavors of milk. E. S. Guthrie, C. L. Roadhouse, and G. A. Richardson. Hilgardia [Calif. Sta.], vol. 5, no. 14, p. 425–453, illus. 1931.

Operation and care of the cream separator, including field data on separators in Idaho. F. W. Atkeson and D. L. Fourt. Idaho Sta. Circ. 61, 16 p., illus. 1930.

Factors affecting the heat coagulation of homogenized coffee cream. P. H. Tracy and H. A. Ruehe. Ill. Sta. Bul. 352, p. 569–578. [1930.]

How the cream layer forms on milk. A. C. Dahlberg and J. C. Marquardt. N. Y. State Sta. Bul. 591, 11 p., illus. 1931.

The creaming of raw milk. A. C. Dahlberg and J. C. Marquardt. N. Y. State Sta. Bul. 593, 11 p., illus. 1931.

Straining milk on the farm. A. C. Dahlberg. N. Y. State Sta. Bul. 585, 22 p., illus. 1930.

The bacterial flora of aseptically drawn milk. W. Dorner. N. Y. State Sta. Tech. Bul. 165, 39 p. 1930.

Preparing samples of milk for the methylene blue reduction test. H. B. Ellenberger and R. I. Moody. Vt. Sta. Bul. 312, 23 p. 1930.

Variability, accuracy and adaptability of some common methods of determining the keeping quality of milk.—I, Methods of comparison. A. H. Robertson and J. M. Frayer. Vt. Sta. Bul. 314, 46 p., illus. 1930.

Variability, accuracy and adaptability of some common methods of determining the keeping quality of milk.—II, Observations in sextuplicate. A. H. Robertson, R. I. Moody, and J. M. Frayer. Vt. Sta. Bul. 315, 39 p., illus. 1930.

Variability, accuracy and adaptability of some common methods of determining the keeping quality of milk.—III, Observations at different temperatures and at successive intervals on the same sample. A. H. Robertson and J. M. Frayer. Vt. Sta. Bul. 316, 55 p., illus. 1930.

Variability, accuracy and adaptability of some common methods of determining the keeping quality of milk.—IV, Correlation studies. A. H. Robertson and J. M. Frayer. Vt. Sta. Bul. 317, 154 p., illus. 1930.

Variability, accuracy and adaptability of some common methods of determining the keeping quality of milk.—V, The broader aspects of variability. A. H. Robertson and J. M. Frayer. Vt. Sta. Bul. 318, 54 p., illus. 1930.

The production of high quality milk.—II, The influence of delayed cooling upon the quality of milk. J. M. Frayer. Vt. Sta. Bul. 313, 34 p., illus. 1930.

The production of high quality milk.—III, Electric cooling versus ice cooling. J. A. Newlander. Vt. Sta. Bul. 326, 14 p., illus. 1931.

The cost of cooling milk with electricity. E. O. Anderson. Conn. Storrs Sta. Bul. 170, 23 p., illus. 1930.

How to whip cream. J. C. Hening. N. Y. State Sta. Circ. 115, 5 p., illus. 1930.

Pasteurizing milk for calf feeding. C. L. Roadhouse and R. L. Perry. Calif. Sta. Circ. 319, 24 p., illus. 1930.

Bacteriology of butter.—I, Influence of the distribution of the non-fatty constituents on the changes in bacterial content during holding. B. W. Hammer and R. V. Hussong. Iowa Sta. Research Bul. 134, p. 17–30. 1930.

Fat losses in buttermilk. W. B. Combs and S. T. Coulter. Minn. Sta. Bul. 273, 30 p., illus. 1930.

Some of the factors influencing the growth of molds in butter. H. Macy. Minn. Sta. Tech. Bul. 64, 86 p., illus. 1929.

Standardization of milk with skimmilk powder for the manufacture of Cheddar cheese. H. C. Hansen and D. R. Theophilus. Idaho Sta. Bul. 174, 16 p. 1930.

Standardization of milk for the manufacture of American cheese. W. V. Price and L. Germain. Wis. Sta. Research Bul. 108, 11 p., illus. 1931.

The utilization of dry skimmilk in the manufacture of ice cream and cream cheese. J. C. Marquardt. N. Y. State Sta. Tech. Bul. 174, 24 p. 1931.

A nonacid Babcock method for determining fat in ice cream. O. R. Overman and O. F. Garrett. Ill. Sta. Bul. 360, p. 393–406. 1930.

Frozen sweet cream as an ingredient of ice cream. M. J. Mack. Mass. Sta. Bul. 268, p. 183–193, illus. 1930.

Packaged ice cream. K. E. Wright. Mass. Sta. Bul. 269, p. 195–206, illus. 1930.

The influence of sugar and butterfat on quality of ice cream. P. S. Lucas, T. Matsui, and D. E. Mook. Mich. Sta. Spec. Bul. 201, 22 p. 1930.

Testing ice cream for butterfat. L. K. Crowe. Nebr. Sta. Bul. 246, 16 p. 1930.

Dry skimmilk in ice cream. W. V. Price and R. Whitaker. N. Y. Cornell Sta. Bul. 516, 37 p., illus. 1931.

Effect of carbonation on bacterial content and keeping quality of dairy products. M. J. Prucha, J. M. Brannon, and H. A. Ruehe. Ill. Sta. Bul. 368, p. 143–163, illus. 1931.

Studies on the Coccaceae.—XVI, The genus Leuconostoc. G. J. Hucker and C. S. Pederson. N. Y. State Sta. Tech. Bul. 167, 80 p., illus. 1930.

DISEASES OF LIVESTOCK

Answers to questions regarding bovine infectious abortion. R. Graham and F. Thorp, jr. Ill. Sta. Circ. 360, 32 p., illus. 1930.

Bang's abortion disease. H. Morris. La. Stas. Circ. 3, 8 p. 1930.

Studies of the test tube agglutination test for the diagnosis of Bang's disease (contagious abortion). C. P. Fitch, C. R. Donham, L. M. Bishop, and W. L. Boyd. Minn. Sta. Tech. Bul. 73, 56 p., illus. 1930.

Contagious abortion of cattle. D. S. Buchanan and C. B. Cain. Miss. Sta. Circ. 90, 4 p. 1930.

Prevention and eradication of infectious abortion in cattle. J. W. Connaway. Mo. Sta. Bul. 290, 21 p. 1930.

Economic aspects of contagious abortion in a dairy herd. R. F. Morgan and H. P. Davis. Nebr. Sta. Research Bul. 46, 54 p., illus. 1930.

Control and eradication of Bang's abortion disease. D. E. Madsen and W. H. Hendricks. Utah Sta. Circ. 94, 8 p., illus. 1931.

Infectious bronchitis in fowls. G. Kernohan. Calif. Sta. Bul. 494, 22 p., illus. 1930.
Infectious bronchitis. F. R. Beaudette and C. B. Hudson. N. J. Stas. Hints to Poultrymen, vol. 18, no. 12, 4 p. 1930.
Coccidiosis in fowls. A. J. Durant. Mo. Sta. Bul. 289, 8 p., illus., 1930.
Coccidiosis of chickens. D. E. Madsen. Utah Sta. Circ. 86, 4 p., illus. 1930.
Vaccinating fowls for chicken pox. W. A. James and R. Graham. Ill. Sta. Circ. 363, 14 p., illus. 1930.
Fowl-pox control. W. T. Johnson. Oreg. Sta. Bul. 273, 24 p., illus. 1930.
Leukemia in fowls. A. J. Durant. Mo. Sta. Bul. 295, 8 p., illus. 1930.
Bacillary white diarrhea and related diseases of chickens. P. R. Edwards and F. E. Hull. Ky. Sta. Bul. 296, p. 235–280, illus. 1929.
Tenth annual report on eradication of pullorum disease in Massachusetts, 1929–1930. H. Van Roekel, K. L. Bullis, and G. L. Dunlap. Mass. Sta. Control Ser. Bul. 53, 23 p., illus. 1930.
Studies on bacteriophage in relation to Salmonella and pullorum disease. W. L. Mallmann. Mich. Sta. Tech. Bul. 109, 15 p. 1931.
Ten thousand autopsies. F. R. Beaudette and C. B. Hudson. N. J. Stas. Hints to Poultrymen, vol. 19, no. 6, 4 p. 1931.
Short interval testing as a control of pullorum disease. R. S. Dearstyne, R. E. Greaves, and H. C. Gauger. N. C. Sta. Tech. Bul. 40, 31 p., illus. 1931.
Pullorum disease. A. Broerman. Ohio Sta. Spec. Circ. 33, 8 p. [1931.]
Sodium acid sulphate as a disinfectant against *Salmonella pullorum* in poultry-yard soils, a preliminary study. P. W. Allen and M. Jacob. Tenn. Sta. Bul. 143, 14 p., illus. 1930.
Pullorum disease (bacillary white diarrhea). C. E. Sawyer and C. M. Hamilton. West. Wash. Sta. Bul. 17–W, 19 p., illus. 1930.
Studies on roup vaccination in chickens. C. Elder, F. J. Kohn, and A. M. Lee. Wyo. Sta. Bul. 172, 47 p., illus. 1930.
Diseases of poultry. I. E. Newson. Colo. Sta. Bul. 372, 42 p., illus. 1930.
Studies in fascioliasis in Oregon sheep and goats. J. N. Shaw and B. T. Simms. Oreg. Sta. Bul. 266, 24 p., illus. 1930.
Hog cholera and allied diseases. G. H. Glover. Colo. Sta. Bul. 358, 10 p. 1930.
Factors that influence the development and survival of the ova of an ascarid roundworm, *Toxocara canis* (Werner, 1782) Stiles, 1905, under field conditions. W. B. Owen. Minn. Sta. Tech. Bul. 71, 25 p., illus. 1930.
Infectious trachitis. C. S. Gibbs. Mass. Sta. Bul. 273, p. 27–55, illus. 1931.
The incidence of avian tuberculosis in mammals other than swine. L. Van Es and H. M. Martin. Nebr. Sta. Research Bul. 49, 132 p. 1930.
A contribution to the bacteriology and pathology of the bovine udder. L. B. Sholl and J. P. Torrey. Mich. Sta. Tech. Bul. 110, 31 p., illus. 1931.
Miscellaneous parasites. F. R. Beaudette. N. J. Stas. Hints to Poultrymen, vol. 18, no. 10, 4 p., illus. 1930.
Feeding value of alfalfa hay treated with calcium arsenate. H. J. Frederick. Utah Sta. Bul. 223, 8 p., illus. 1930.
Indiana plants injurious to livestock. A. H. Hansen. Ind. Sta. Circ. 175, 38 p., illus. 1930.
Principal poisonous plants in Kansas. F. C. Gates. Kans. Sta. Tech. Bul. 25, 67 p., illus. 1930.

AGRICULTURAL ENGINEERING

Air cleaners for motor vehicles. A. H. Hoffman. Calif. Sta. Bul. 499, 66 p., illus. 1930.
Dusts used for testing air cleaner efficiency. A. H. Hoffman. Hilgardia [Calif. Sta.], vol. 5, no. 2, p. 17–33, illus. 1930.
Tractors and trucks on Louisiana rice farms, 1929 (with supplementary data on labor requirements). R. J. Saville and G. H. Reuss. La. Stas. Bul. 218, 39 p. 1930.
Tractor hitches. H. E. Murdock. Mont. Sta. Bul. 229, 34 p., illus. 1930.
Mechanical tests on tractor farming equipment. A progress report. H. E. Murdock. Mont. Sta. Bul. 243, 52 p., illus. 1931.
An economic study of tractors on New York farms. C. W. Gilbert. N. Y. Cornell Sta. Bul. 506, 80 p., illus. 1930.
Motor trucks on New York farms. C. W. Gilbert. N. Y. Cornell Sta. Bul. 507, 55 p., illus. 1930.
Harvesting cornstalks for industrial uses. J. B. Davidson and E. V. Collins. Iowa Sta. Bul. 274, p. 373–394, illus. 1930.
Combine harvester threshers in Michigan. E. C. Sauve. Mich. Sta. Spec. Bul. 198, 19 p., illus. 1930.
Cost of combine harvesting in Minnesota. G. A. Pond and L. B. Bassett. Minn. Sta. Bul. 266, 31 p., illus. 1930.
The combined harvester-thresher in Montana. A. E. Starch and R. M. Merrill. Mont. Sta. Bul. 230, 59 p., illus. 1930.
The harvester-stacker method of harvesting grain in North Dakota. H. F. McColly. N. Dak. Sta. Bul. 245, 27 p., illus. 1930.
Combining grain in weed-free fields. Progress report on combine project for 1929. D. E. Wiant and R. L. Patty. S. Dak. Sta. Bul. 251, 11 p., illus. 1930.
Operating ensilage cutters and husker-shredders with electric motors. T. E. Hienton. Ind. Sta. Circ. 174, 4 p., illus. 1930.
The use of a small electric motor in silo filling. E. E. Brackett and E. B. Lewis. Nebr. Sta. Circ. 42, 10 p., illus. 1930.
Installation of motor-driven feed grinders. T. E. Hienton. Ind. Sta. Circ. 173, 4 p., illus. 1930.
Milk cooling on California dairy farms. B. D. Moses and J. R. Tavernetti. Calif. Sta. Bul. 495, 34 p., illus. 1930.
The mechanical dairy cooler on Nebraska farms, a study of four walk-in type installations. E. E. Brackett and E. B. Lewis. Nebr. Sta. Bul. 249, 22 p., illus. 1930.
Mechanical refrigeration of milk in a tank type refrigerator. F. E. Price, C. J. Hurd, and G. V. Copson. Oreg. Sta. Bul. 268, 27 p., illus. 1930.
Electric laundry equipment on the farm. W. T. Ackerman. N. H. Sta. Circ. 34, 15 p., illus. 1930.
Sources of power on Minnesota farms. W. L. Cavert. Minn. Sta. Bul. 262, 72 p., illus. 1930.
Rural electric service in Nebraska. Farm line extensions of 1929 compared with those of 1927. E. E. Brackett and E. B. Lewis. Nebr. Sta. Bul. 254, 23 p., illus. 1931.
Stationary spray systems in West Virginia. F. D. Cornell, jr. W. Va. Sta. Bul. 239, 28 p., illus. 1931.
The farm shop. L. J. Smith and H. L. Garver. Wash Col. Sta. Pop. Bul. 147, 24 p., illus. 1930.
Directions for building Illinois shed-roof poultry house. E. G. Johnson and H. H. Alp. Ill. Sta. Circ. 368, 4 p., illus. 1931.

The relation of environmental conditions in poultry houses to winter egg production. C. W. Smith. Nebr. Sta. Bul. 247, 34 p., illus. 1930.

New Jersey brooder house or small laying house. J. C. Taylor and E. R. Gross. N. J. Stas. Hints to Poultrymen, vol. 19, no. 5, 4 p., illus. 1931.

The 1931 modification of plans for the New Jersey multiple unit laying house. W. C. Thompson, L. M. Black, and E. R. Gross. N. J. Stas. Hints to Poultrymen, vol. 19, no. 8, 4 p., illus. 1931.

Plans and list of materials for the New Jersey multiple unit laying house, 1931 modification. W. C. Thompson, L. M. Black, and E. R. Gross. N. J. Stas. Hints to Poultrymen, vol. 19, no. 9, 4 p., illus. 1931.

The trench silo. J. C. Grimes and M. L. Nichols. Ala. Sta. Circ. 59, 8 p., illus. 1931.

Silage and silo construction. R. H. Lush and H. T. Barr. La. Stas. Circ. 2, 20 p. 1930.

A plan for the milk house. W. A. Foster, H. A. Ruehe, and C. S. Rhode. Ill. Sta. Circ. 371, 4 p., illus. 1931.

Remodelling farm house cellars for the storage of potatoes. O. R. Butler. N. H. Sta. Circ. 36, 4 p., illus. 1931.

Precooling of fresh fruits and temperatures of refrigerator cars and warehouse rooms. E. L. Overholser and B. D. Moses. Calif. Sta. Bul. 496, 34 p., illus. 1930.

Water supply and sewage disposal systems for farm homes. I. D. Wood and E. B. Lewis. Nebr. Sta. Bul. 245, 44 p., illus. 1930.

Annual report of the Department of Sewage Disposal, July 1, 1929–June 30, 1930. W. Rudolfs. N. J. Stas. Bul. 521, 47 p., illus. 1931.

Cost of pumping and duty of water for rice on the Grand Prairie of Arkansas. B. S. Clayton. Ark. Sta. Bul. 261, 48 p., illus. 1931.

Rice farm irrigation systems in Louisiana, 1929. R. J. Saville. La. Stas. Bul. 216, 19 p. 1930.

Progress report of the irrigated eighty-acre demonstration farm unit of the Harney Branch Experiment Station, 1927–1930. O. Shattuck and R. E. Hutchison. Oreg. Sta. Bul. 270, 38 p., illus. 1930.

Twenty-eight years of irrigation experiments near Logan, Utah, 1902–29, inclusive. D. W. Pittman and G. Stewart. Utah Sta. Bul. 219, 15 p., illus. 1930.

The ground water of Middle Rio Grande Valley and its relation to drainage. D. W. Bloodgood. N. Mex. Sta. Bul. 184, 60 p., illus. 1930.

Orchard drainage in the Medford area, Jackson County, Oregon. M. R. Lewis and A. Work. Oreg. Sta. Circ. 100, 24 p., illus. 1931.

Drainage and improvement of wet land. W. L. Powers. Oreg. Sta. Circ. 102, 19 p., illus. 1931.

Torrential floods in northern Utah, 1930. Report of Special Flood Commission. S. Q. Cannon et al. Utah Sta. Circ. 92, 51 p., illus. 1931.

Soil erosion, a local and national problem. C. G. Bates and O. R. Zeasman. Wis. Sta. Research Bul. 99, 100 p., illus. 1930.

ECONOMICS AND SOCIOLOGY

FARM MANAGEMENT AND PRODUCTION

An economic study of range sheep production in Arizona. K. P. Pickrell and E. B. Stanley. Ariz. Sta. Bul. 134, p. 519–551, illus. 1930.

Rice farming in Arkansas with financial results for 1927. O. J. Hall. Ark. Sta. Bul. 260, 56 p., illus. 1931.

An economic survey of the Los Angeles milk market. L. Spencer. Calif. Sta. Bul. 513, 106 p., illus. 1931.

An economic study of the agriculture of the Connecticut Valley: 3, Tobacco farm organization. C. I. Hendrickson. Conn. Storrs Sta. Bul. 165, p. 109–143, illus. 1930.

Farming systems for eastern Washington and northern Idaho. G. Severance, B. Hunter, and P. Eke. Idaho Sta. Bul. 173, 83 p., illus. 1930. (Also published as Wash. Col. Sta. Bul. 244.)

Bulk handling grain from the hillside type combine. H. Beresford and E. N. Humphrey. Idaho Sta. Bul. 175, 19 p., illus. 1930.

Types of farming in Indiana. E. C. Young and F. F. Elliott. Ind. Sta. Bul. 342, 72 p., illus. 1930.

The livestock system in Iowa County. J. A. Hopkins, jr., and R. S. Kifer. Iowa Sta. Bul. 270, p. 205–236, illus. 1930.

Types of farming in Kansas. J. A. Hodges, F. F. Elliott, and W. E. Grimes. Kans. Sta. Bul. 251, 112 p., illus. 1930.

Farm management and incomes of farm families in Laurel County, Kentucky. W. D. Nicholls and H. W. Hawthorne. Ky. Sta. Bul. 305, p. 219–283, illus. 1930.

The budget method of improving farm organization and management. W. G. Finn and Z. L. Galloway. Ky. Sta. Bul. 312, p. 601–628, illus. 1930.

An economic study of factors affecting farm organization and power utilization of sugar cane farms, 1929. G. H. Reuss. La. Stas. Bul. 215, 78 p., illus. 1930.

Some economic problems in the rice farming area, 1929. R. J. Saville. La. Stas. Bul. 217, 65 p., illus. 1930.

Part-time farming in Massachusetts. D. Rozman. Mass. Sta. Bul. 266, p. 104–146, illus. 1930.

Types of farming in Michigan. E. B. Hill, F. T. Riddell, and F. F. Elliott. Mich. Sta. Spec. Bul. 206, 83 p., illus. 1930.

Systems of farming in northwestern Minnesota. L. F. Garey and F. F. Elliott. Minn. Sta. Bul. 268, 20 p., illus. 1930. (Sup. to Minn. Sta. Bul. 257.)

Factors affecting the physical and economic costs of butterfat production in Pine County, Minnesota. G. A. Pond and M. Ezekiel. Minn. Sta. Bul. 270, 41 p., illus. 1930.

Farm practices in south central Mississippi with suggested changes. L. E. Long and R. S. Kifer. Miss. Sta. Bul. 276, 59 p., illus. 1929.

Making cotton cheaper. Can present production costs be reduced? M. G. Vaiden, J. O. Smith, and W. E. Ayres. Miss. Sta. Bul. 290, 32 p., illus. 1931.

Farm management and net income, a comparison of Choctaw County farms having high and low net cash incomes, 1928. L. E. Long. Miss. Sta. Circ. 89, 5 p. 1930.

Influence of yield on costs and income in agricultural production. B. H. Frame. Mo. Sta. Bul. 297, 12 p. 1931.

Successful farming practices in the Billings beet region. E. J. Bell, jr. Mont. Sta. Bul. 232, 44 p., illus. 1930.

An economic analysis of production problems on the Flathead Irrigation Project. S. E. Johnson. Mont. Sta. Bul. 237, 88 p., illus. 1930.

Present and prospective development of farming systems in western Montana. S. E. Johnson. Mont. Sta. Bul. 239, 72 p., illus. 1930.

Types of ranches and operating practices in relation to costs, investment, and income in the range beef cattle industry of Montana. Preliminary report. M. H. Saunderson and D. E. Richards. Mont. Sta. Bul. 244, 20 p., illus. 1931.

Types of farming in Nebraska. H. Hedges and F. F. Elliott. Nebr. Sta. Bul. 244, 76 p., illus. 1930.

A five-year economic study of 125 farms in Curry and Roosevelt Counties, New Mexico: Part I of Economics of agriculture on dry-land farms in eastern New Mexico. L. H. Hauter, A. L. Walker, and O. V. Wells. N. Mex. Sta. Bul. 186, 70 p., illus. 1930.

Production requirements, costs, and returns from dry-land farming in eastern New Mexico: Part II of Economics of agriculture on dry-land farms in eastern New Mexico. L. H. Hauter, A. L. Walker, and O. V. Wells. N. Mex. Sta. Bul. 187, 59 p., illus. 1930.

Selecting the most profitable system of dry-land farming in eastern New Mexico: Part III of Economics of agriculture on dry-land farms in eastern New Mexico. L. H. Hauter, A. L. Walker, and O. V. Wells. N. Mex. Sta. Bul. 188, 41 p., illus. 1931.

A statistical study of milk production for the New York market. M. P. Catherwood. N. Y. Cornell Sta. Bul. 518, 126 p., illus. 1931.

Ranch organization and management in western North Dakota. M. B. Johnson. N. Dak. Sta. Bul. 237, 78 p., illus. 1930.

Variations in crop production costs in Medina County, Ohio. F. L. Morison. Ohio Sta. Bul. 453, 52 p. 1930.

The cost of developing an apple orchard. C. W. Ellenwood. Ohio Sta. Bul. 456, 30 p., illus. 1930.

Cost and efficiency in pear production in the Rogue River Valley. R. S. Besse, W. S. Brown, and L. P. Wilcox. Oreg. Sta. Bul. 267, 56 p., illus. 1930.

An economic study of the small-fruit industry in Oregon. G. L. Sulerud and M. N. Nelson. Oreg. Sta. Bul. 274, 95 p., illus. 1931.

Land utilization and farm management in Wyoming County. P. I. Wrigley. Pa. Sta. Bul. 257, 40 p., illus. 1930.

Growing and marketing grapes in Erie County, Pennsylvania. J. T. Vandenburg, jr., and G. P. Scoville. Pa. Sta. Bul. 260, 40 p., illus. 1930.

Pee Dee farm management studies, 1925–1930. W. C. Jensen and B. A. Russell. S. C. Sta. Bul. 269, 80 p., illus. 1931.

Newer truck crop area studies. A preliminary report. W. C. Jensen and C. Gunnells. S. C. Sta. Circ. 45, 31 p., illus. 1931.

Piedmont farm management for 1931. W. C. Jensen and B. A. Russell. S. C. Sta. Circ. 46, 15 p. 1931.

Economic adjustments on farms in southeastern South Dakota. R. H. Rogers. S. Dak. Sta. Bul. 249, 47 p., illus. 1930.

Cattle ranch organization and management in western South Dakota. M. B. Johnson. S. Dak. Sta. Bul. 255, 55 p., illus. 1930.

Planning the ranch for greater profit: A study of physical and economic factors affecting organization and management of ranches in the Edwards Plateau grazing area. L. P. Gabbard, C. A. Bonnen, and J. N. Tate. Tex. Sta. Bul. 413, 45 p., illus. 1930.

Type-of-farming areas in Texas. C. A. Bonnen and F. F. Elliott. Tex. Sta. Bul. 427, 84 p., illus. 1931.

Systems of dairy farm management for the Richmond milk producing area. J. L. Maxton, R. S. Kifer, and J. J. Vernon. Va. Sta. Bul. 272, 95 p., illus. 1930.

Economic aspects of the Washington fruit industry: Apricots, cherries, peaches, and pears. N. W. Johnson. Wash. Col. Sta. Bul. 238, 72 p., illus. 1930.

Economic aspects of apple production in Washington. N. W. Johnson. Wash. Col. Sta. Bul. 239, 79 p., illus. 1930.

Farming systems for eastern Washington and northern Idaho. G. Severance, B. Hunter, and P. Eke. Wash. Col. Sta. Bul. 244, 83 p., illus. 1930. (Also published as Idaho Sta. Bul. 173.)

MARKETING AND PRICES

A study of the shipment of fresh fruits and vegetables to the Far East. E. L. Overholser. Calif. Sta. Bul. 497, 77 p., illus. 1930.

Marketing California apples. E. A. Stokdyk, H. E. Erdman, C. H. West, and F. W. Allen. Calif. Sta. Bul. 501, 151 p., illus. 1930.

Series on California crops and prices: Wheat. E. W. Braun. Calif. Sta. Bul. 502, 34 p., illus. 1930.

Series on California crops and prices: Olives. H. R. Wellman. Calif. Sta. Bul. 510, 27 p., illus. 1931.

Series on California crops and prices: Barley. E. W. Braun. Calif. Sta. Bul. 512, 32 p., illus. 1931.

The marketing of Delaware cantaloupes.—Part I. H. S. Gabriel. Del Sta. Bul. 165, 24 p., illus. 1930.

A study of the cost of transportation of Florida citrus fruits with comparative costs from other producing areas. M. A. Brooker. Fla. Sta. Bul. 217, 128 p., illus. 1930.

Farm prices of cotton related to quality, Georgia crop, 1928–29. L. D. Howell and W. T. Fullilove. Ga. Sta. Bul. 165, 33 p., illus. 1930.

Steer prices in relation to Idaho beef producers' problems. R. B. Heflebower. Idaho Sta. Bul. 172, 32 p., illus. 1930.

Prices of Illinois farm products from 1866 to 1929. L. J. Norton and B. B. Wilson. Ill. Sta. Bul. 351, p. 487–566, illus. 1930.

Prices of Illinois farm products from 1921 to 1929. L. J. Norton. Ill. Sta. Bul. 363, p. 517–599, illus. 1930.

Prices of Illinois farm products in 1930. L. J. Norton. Ill. Sta. Bul. 365, 32 p., illus. 1931.

Price plans for marketing milk. R. W. Bartlett. Ill. Sta. Circ. 358, 19 p., illus. 1930.

Business procedure in shipping grain direct from producing to consuming sections. L. F. Rickey. Ill. Sta. Circ. 359, 20 p., illus. 1930.

The marketing of eggs on a graded basis. E. R. Menefee. Ind. Sta. Bul. 334, 19 p., illus. 1929.

Marketing Indiana timber. W. L. Neubrech. Ind. Sta. Bul. 335, 64 p., illus. 1930.

Buying tomatoes on grade 1929. F. C. Gaylord and J. H. MacGillivray. Ind. Sta. Bul. 336, 19 p., illus. 1930.

Motor transportation of hogs to the Indianapolis market. J. R. Wiley. Ind. Sta. Bul. 337, 30 p., illus. 1930.

Quality as a factor in the price of Kentucky lambs. E. C. Johnson and C. D. Phillips. Ky. Sta. Bul. 302, p. 91–122, illus. 1930.

Financing production and marketing of Louisiana strawberries and suggested reorganization. R. L. Thompson. La. Stas. Bul. 219, 67 p., illus. 1931.

Cotton price-quality relationships in local markets of Louisiana. C. C. Farrington. La. Stas. Bul. 221, 59 p., illus. 1931.

Local market requirements of agricultural products in Aroostook County, Maine. C. H. Merchant and B. T. Smith. Me. Sta. Bul. 355, p. 39–106, illus. 1930.
Prices paid for Maryland farm products, 1851–1927. R. F. Hale. Md. Sta. Bul. 321, 206+2 p., illus. 1930.
Consumer demand for apples in Michigan. H. P. Gaston. Mich. Sta. Spec. Bul. 209, 50 p., illus. 1931.
The Lansing food survey. C. A. Scholl and W. O. Hedrick. Mich. Sta. Tech. Bul. 107, 152 p., illus. 1930.
Factors affecting sweet potato prices in Missouri. F. L. Thomsen and W. R. Fankhanel. Mo. Sta. Bul. 302, 20 p., illus. 1931.
Marketing stock hogs in Missouri. P. Richards and F. L. Thomsen. Mo. Sta. Research Bul. 146, 70 p., illus. 1930.
Variations in local prices for farm products and supplies in Missouri. F. L. Thomsen. Mo. Sta. Research Bul. 151, 59 p., illus. 1930.
The motor truck as a carrier of fruits and vegetables to Greater New York. B. M. Price. N. J. Stas. Bul. 503, 88 p., illus. 1930.
The consumption of dairy products in six New Jersey townships. W. C. Waite and C. B. Howe. N. J. Stas. Bul. 506, 47 p., illus. 1930.
The milk supply of the New Jersey metropolitan market, including some comments concerning sales in the north shore and the rural markets. C. B. Howe. N. J. Stas. Bul. 515, 24 p. 1930.
A cooperative marketing manual. J. G. Knapp. N. C. Sta. Bul. 276, 80 p. 1930.
Cooperative marketing of dairy products. H. G. Anderson and A. H. Benton. N. Dak. Sta. Bul. 238, 115 p., illus. 1930.
Some factors affecting the movement of Ohio wheat. L. G. Foster. Ohio Sta. Bul. 458, 48 p., illus. 1930.
The development of market milk areas in northeastern Ohio. C. G. McBride. Ohio Sta. Bul. 469, 43 p., illus. 1930.
The market situation and outlook for the Oregon canned fresh prune. M. N. Nelson and W. H. Belden. Oreg. Sta. Bul. 263, 30 p., illus. 1930.
Lamb marketing investigations in western Oregon. H. A. Lindgren and E. L. Potter. Oreg. Sta. Bul. 265, 15 p., illus. 1930.
A price plan for selling milk by collective bargaining organizations. R. W. Bartlett. Pa. Sta. Bul. 251, 32 p., illus. 1930.
Membership problems in a milk marketing organization. J. K. Stern. Pa. Sta. Bul. 256, 16 p. 1930.
The feed purchasing power of eggs. E. M. Funk. Pa. Sta. Bul. 262, 15 p., illus. 1931.
A study of apple containers. R. B. Corbett and E. P. Christopher. R. I. Sta. Bul. 227, 14 p., illus. 1931.
Cotton marketing studies, 1925–1930. W. C. Jensen, M. Guin, and H. A. White. S. C. Sta. Bul. 270, 79 p., illus. 1931.
The grade and staple of South Carolina's 1930 cotton crop. H. A. White. S. C. Sta. Circ. 47, 15 p., illus. 1931.
Prices of farm products in Utah. W. P. Thomas. Utah Sta. Bul. 217, 60 p., illus. 1930.
Marketing fluid milk in four Virginia cities. J. L. Maxton and C. C. Taylor. Va. Sta. Bul. 275, 42 p., illus. 1930.
Washington apple prices and costs of shipping point marketing services. C. C. Hampson and E. F. Dummeier. Wash. Col. Sta. Bul. 242, 111 p., illus. 1930.
The West Virginia community packing house at Inwood as a State service to apple growing. F. J. Schneiderhan, W. Va. Sta. Bul. 238, 24 p., illus. 1930.

TAXATION, CREDIT, AND TENANCY

Cost of public education from viewpoint of agriculture in Larimer County, Colorado. G. S. Klemmedson. Colo. Sta. Bul. 368, 66 p., illus. 1930.
Taxation in Connecticut, a preliminary survey with emphasis upon its relation to agriculture. M. S. Kendrick. Conn. Storrs Sta. Bul. 166, p. 147–188, illus. 1930.
School financing in Michigan. A plan to equalize the burden. F. M. Thrun. Mich. Sta. Spec. Bul. 212, 79 p., illus. 1931.
The rural tax situation in Choctaw County, Miss., 1928. L. E. Long. Miss. Sta. Bul. 282, 70 p., illus. 1930.
The Missouri farmers' tax position. C. H. Hammar. Mo. Sta. Bul. 291, 28 p., illus. 1930.
The collection of taxes by the State of New York and the division of these revenues with units of local government. M. S. Kendrick. N. Y. Cornell Sta. Bul. 511, 53 p., illus. 1930.
Taxation as related to the property and income of Ohio farmers. H. R. Moore. Ohio Sta. Bul. 459, 41 p., illus. 1930.
The rural tax problem in Pennsylvania. F. P. Weaver. Pa. Sta. Bul. 263, 35 p., illus. 1931.
Organization and management of agricultural credit corporations in Arkansas. B. M. Gile. Ark. Sta. Bul. 259, 55 p., illus. 1931.
Long term loans of Iowa banks. F. L. Garlock. Iowa Sta. Research Bul. 129, p. 253–300, illus. 1930.
The agricultural credit situation in Kentucky. H. B. Price, C. J. Bradley, and E. C. Johnson. Ky. Sta. Bul. 311, p. 547–600, illus. 1930.
Farm credit in North Carolina, its cost, risk and management. D. L. Wickens and G. W. Forster. N. C. Sta. Bul. 270, 128 p., illus. 1930.
Credit problems of North Carolina cropper farmers. H. H. Wooten. N. C. Sta. Bul. 271, 42 p., illus. 1930.
Credit problems of Oklahoma cotton farmers, with special reference to Garvin, Jackson, and Pittsburg Counties. A. N. Moore and J. T. Sanders. Okla. Sta. Bul. 198, 61 p., illus. 1930.
Farm tenancy in central Kentucky. W. D. Nicholls. Ky. Sta. Bul. 303, p. 123–185, illus. 1930.
Share leasing contracts. W. D. Nicholls. Ky. Sta. Bul. 307, p. 417–443. 1930.
Stock share renting in Virginia. R. A. Ballinger. Va. Sta. Bul. 271, 54 p., illus. 1930.
Land survey of the town of Durham, New Hampshire. C. E. Walker. N. H. Sta. Bul. 255, 23 p., illus. 1931.

SOCIOLOGY

The population of Iowa, its composition and changes, a brief sociological study of Iowa's human assets. W. L. Harter and R. E. Stewart. Iowa Sta. Bul. 275, 63 p., illus. 1930.
Social and economic effects of land speculation on farm families in central Kentucky. M. Oyler. Ky. Sta. Bul. 300, p. 31–64, illus. 1930.
Cost of living and population trends in Laurel County, Kentucky. M. Oyler. Ky. Sta. Bul. 301, p. 65–90, illus. 1930.
Public health and educational services in Michigan. C. R. Hoffer. Mich. Sta. Spec. Bul. 207, 34 p., illus. 1931.
Services of institutions and organizations in town-country communities. C. R. Hoffer and M. Cawood. Mich. Sta. Spec. Bul. 208, 37 p. 1931.

Farm trade centers in Minnesota, 1905–29, a study in rural social organization. C. C. Zimmerman. Minn. Sta. Bul. 269, 70 p., illus. 1930.

Social, economic, and homemaking factors in farm living. R. C. Hill, E. L. Morgan, M. V. Campbell, and O. R. Johnson. Mo. Sta. Research Bul. 148, 90 p., illus. 1930.

A partial sociological study of Dryden, New York, with special emphasis on its historical development. G. M. Kensler and B. L. Melvin. N. Y. Cornell Sta. Bul. 504, 65 p., illus. 1930.

Migration of sons and daughters of white farmers in Wake County, 1929. W. A. Anderson and C. P. Loomis. N. C. Sta. Bul. 275, 24 p., illus. 1930.

Movement of open country population in Ohio. C. E. Lively and P. G. Beck. Ohio Sta. Bul. 467, 48 p., illus. 1930.

Family living expenditures on Ohio farms. C. E. Lively. Ohio Sta. Bul. 468, 36 p., illus. 1930.

A study of certain cash expenditures of Ohio farm families. G. Brinton. Ohio Sta. Bul. 474, 51 p. 1931.

The relations of economic, social, and educational advancement of farmers to their membership in organizations. L. D. Howell. Okla. Sta. Bul. 185, 54 p., illus. 1929.

The economic and social aspects of mobility of Oklahoma farmers. J. T. Sanders. Okla. Sta. Bul. 195, 71 p., illus. 1929.

The high school education of farm boys and girls in South Dakota. W. F. Kumlien. S. Dak. Sta. Bul. 250, 62 p., illus. 1930.

The negro church in rural Virginia. C. H. Hamilton and J. M. Ellison. Va. Sta. Bul. 273, 40 p., illus. 1930.

Young people's organizations in relation to rural life in Virginia, with special reference to 4-H clubs. [Section I–III.] W. E. Garnett. IV, Effects of club work on school work. F. H. Stubbs. Va. Sta. Bul. 274, 87 p., illus. 1930.

MISCELLANEOUS

Economic problems of California agriculture, a report to the Governor of California. Calif. Sta. Bul. 504, 78 p. 1930.

Farm accounts that count. R. R. Hudelson. Ill. Sta. Circ. 362, 20 p., illus. 1931.

Some evidences of agricultural progress. H. W. Mumford. Ill. Sta. Circ. 365, 20 p. 1931.

Agricultural outlook for Illinois, 1931. Ill. Sta. Circ. 366, 24 p., illus. 1931.

Dramatics for farm folks. D. E. Lindstrom. Ill. Sta. Circ. 373, 17 p., illus. 1931.

A partial analysis of the Missouri pig survey reports. F. L. Thomsen and P. Richards. Mo. Sta. Research Bul. 139, 34 p., illus. 1930.

Economic history of the Newlands Irrigation Project. F. B. Headley and C. Venstrom. Nev. Sta. Bul. 120, 30 p., illus. 1930.

Operating costs of retail grain stores in New Hampshire. E. H. Rinear. N. H. Sta. Bul. 251, 32 p., illus. 1930.

An agricultural policy and program for New Jersey. H. J. Baker et al. N. J. Stas. Circ. 225, 125 p. 1930.

Some factors affecting the cost of operation of retail feed stores in New York State. W. Powell. N. Y. Cornell Sta. Bul. 505, 126 p., illus. 1930.

The money income of farm boys in a southern New York dairy region. H. W. Beers. N. Y. Cornell Sta. Bul. 512, 55 p., illus. 1930.

Ohio agricultural statistics for 1929. G. S. Ray, A. R. Tuttle, and R. E. Straszheim. Ohio Sta. Bul. 460, 46 p., illus. 1930.

Four-H club work in West Virginia. T. L. Harris. W. Va. Sta. Bul. 241, 36 p., illus. 1931.

American cheese factories in Wisconsin. H. K. Bakken. Wis. Sta. Research Bul. 100, 30 p., illus. 1930.

The foreign type cheese industry in Wisconsin. W. B. Silcox and H. H. Bakken. Wis. Sta. Research Bul. 103, 36 p., illus. 1930.

REPORTS, PERIODICALS, REGULATORY, AND MISCELLANEOUS PUBLICATIONS

REPORTS

Thirty-ninth annual report, fiscal year ending June 30, 1928, of the agricultural experiment station of the Alabama Polytechnic Institute, Auburn. M. J. Funchess et al. 27 p. [1930.]

Fortieth annual report, fiscal year ending June 30, 1929, of the agricultural experiment station of the Alabama Polytechnic Institute, Auburn. M. J. Funchess et al. 37 p. [1930.]

Forty-first annual report, fiscal year ending June 30, 1930, of the agricultural experiment station of the Alabama Polytechnic Institute, Auburn. M. J. Funchess et al. 38 p. [1931.]

Report of the Alaska Agricultural Experiment Stations, 1929. H. W. Alberts. 58 p., illus. 1930.

Forty-second annual report, fiscal year ending June 30, 1930. D. T. Gray et al. Ark. Sta. Bul. 257, 102 p., illus. 1930.

Report of the agricultural experiment station of the University of California, from July 1, 1929, to June 30, 1930. C. B. Hutchison et al. 114 p., illus. 1931.

The forty-third annual report of the Colorado Agricultural Experiment Station [from December 1, 1929, to June 30, 1930.] C. P. Gillette et al. 44 p. 1930.

Report of the director for the year ending October 31, 1929. W. L. Slate. Conn. State Sta. Bul. 318, p. 751–771. 1930.

Report of the director for the year ending October 31, 1930. W. L. Slate. Conn. State Sta. Bul. 322, p. 111–150, illus. 1931.

Annual report of the director for the fiscal year ending June 30, 1930. C. A. McCue et al. Del. Sta. Bul. 167, 52 p., illus. 1930.

University of Florida Agricultural Experiment Station report for the fiscal year ending June 30, 1929. W. Newell. 102+vi p., illus. [1930.]

University of Florida Agricultural Experiment Station report for the fiscal year ending June 30, 1930. W. Newell. 137+viii p., illus. [1930.]

Forty-third annual report, Georgia Experiment Station, for the year 1930. H. P. Stuckey. 50 p., illus. 1930.

Tenth annual report [Georgia Coastal Plain Station], 1929. S. H. Starr. Ga. Coastal Plain Sta. Bul. 12, 59 p., illus. 1930.

Report of the Guam Agricultural Experiment Station, 1929. C. W. Edwards et al. 20 p., illus. 1931.

Work and progress of the agricultural experiment station for the year ending December 31, 1929. E. J. Iddings. Idaho Sta. Bul. 170, 32 p. 1930.

A year's progress in solving farm problems of Illinois: Annual report of Illinois Agricultural Experiment Station for year ended June 30, 1930. H. W. Mumford et al. 296 p., illus. 1930. Compiled and edited by F. J. Keilholz.

Report of the director [Indiana Station] for the year ending June 30, 1929. J. H. Skinner et al. 95 p., illus. [1929.]

Report of the director [Indiana Station] for the year ending June 30, 1930. J. H. Skinner and H. J. Reed. 116 p., illus. 1930.

Report of the Moses Fell Annex Farm, Bedford, Indiana, June, 1930. H. J. Reed and H. G. Hall. Ind. Sta. Circ. 172, 24 p., illus. 1930.

Iowa Agricultural Experiment Station annual report for fiscal year ending June 30, 1929. C. F. Curtiss. 71 p. 1929.

Iowa Agricultural Experiment Station annual report for fiscal year ending June 30, 1930. C. F. Curtiss. 64 p. 1930.

Director's report [Kansas Station] for the biennium July 1, 1928, to June 30, 1930. L. E. Call. 164 p., illus. 1930.

Forty-first annual report of the Kentucky Agricultural Experiment Station for the year 1928. Part II. 531+26 p., illus. [1929.]

Forty-second annual report of the agricultural experiment station of the University of Kentucky for the year 1929. Part I. T. P. Cooper. 55 p. 1930.

The forty-third annual report of the University of Maryland Agricultural Experiment Station, 1929–1930. H. J. Patterson et al. xxii+326+1 p., illus. 1930.

Annual report of the Massachusetts Agricultural Experiment Station, 1929. F. J. Sievers et al. Mass. Sta. Bul. 260, p. 323–382. 1930.

Annual report of the Massachusetts Agricultural Experiment Station, 1930. F. J. Sievers et al. Mass. Sta. Bul. 271, p. 227–289. 1931.

Sixty-seventh annual report of the secretary of the State Board of Agriculture of the State of Michigan and the forty-first annual report of the experiment station from July 1, 1927, to June 30, 1928. H. H. Halladay and R. S. Shaw. 307 p., illus. 1928.

Sixty-eighth annual report of the secretary of the State board of Agriculture of the State of Michigan and the forty-second annual report of the experiment station from July 1, 1928, to June 30, 1929. H. H. Halladay et al. 231 p., illus. 1929.

[Michigan] Agricultural Experiment Station report, two years ended June 30, 1930. V. R. Gardner. 60 p. [1931.]

[Minnesota] Agricultural Experiment Station, thirty-eighth annual report, July 1, 1929, to June 30, 1930. W. C. Coffey. 80 p. 1930.

Mississippi Agricultural Experiment Station, forty-second annual report for the fiscal year ending June 30, 1929. J. R. Ricks et al. 42 p. [1929.]

Mississippi Agricultural Experiment Station, forty-third annual report for the fiscal year ending June 30, 1930. J. R. Ricks et al. 49 p., illus. [1930.]

Report of the Holly Springs Branch Experiment Station, 1930. T. F. McGehee and O. B. Casanova. Miss. Sta. Bul. 286, 19 p., illus. 1930.

Report of the Raymond Branch Experiment Station, 1930. R. F. Wallace. Miss. Sta. Bul. 287, 20 p., illus. 1930.

Report of the South Mississippi Branch Experiment Station for 1930. J. C. Robert, W. W. Welborne, and J. L. Cooley, jr. Miss. Sta. Bul. 285, 32 p., illus. 1930.

Experiment station research. [Report of Missouri Station, 1929.] F. B. Mumford and S. B. Shirky. Mo. Sta. Bul. 285, 116 p., illus. 1930.

Solving farm problems.—Thirty-sixth annual report of the [Montana] Agricultural Experiment Station, July 1, 1928, to June 30, 1929. F. B. Linfield et al. 95 p., illus. 1930.

Forty-third annual report of the agricultural experiment station of Nebraska, [1929]. W. W. Burr. 52 p. 1930.

Forty-first annual report [New Mexico] Agricultural Experiment Station, 1929–1930. F. Garcia. 108 p., illus. 1930.

[Report of the New York State College of Agriculture, 1930.] A. R. Mann. Part I, The College of Agriculture: Resident and extension instruction. 90 p. Part II, The Cornell University Agricultural Experiment Station. 125 p. [1930.]

Forty-ninth annual report [New York State Station] for the fiscal year ended June 30, 1930. U. P. Hedrick. 99 p. 1931.

Forty-third annual report of the North Carolina Agricultural Experiment Station for the fiscal year ending June 30, 1930. R. Y. Winters et al. 159 p., illus. [1930.]

Experiment station progress: Report for the biennium, July 1, 1927, to June 30, 1929. P. F. Trowbridge et al. N. Dak. Sta. Bul. 233, 134 p., illus. 1930.

Hettinger Substation report for 1929. C. H. Plath. N. Dak. Sta. Bul. 234, 25 p 1930.

Williston Substation report, April 1, 1929, to March 31, 1930. E. G. Schollander. N. Dak. Sta. Bul. 235, 43 p., illus. 1930.

Forty-ninth annual report of the Ohio Agricultural Experiment Station for the year ended June 30, 1930. C. G. Williams et al. Ohio Sta. Bul. 470, 270 p., illus. 1931.

Annual reports of county experiment farms, 1927. Ohio Agricultural Experiment Station. 36 p. [1928.]

Annual reports of county experiment farms, 1928. Ohio Agricultural Experiment Station. 36 p. [1929.]

Annual reports of the county experiment farms, 1929. Ohio Agricultural Experiment Station. 36 p. [1930.]

Research leads to farm progress: Report of Oklahoma Agricultural Experiment Station for July 1, 1926, to June 30, 1930. C. P. Blackwell et al. 351 p., illus. [1930.]

Director's biennial report, 1928–1930, [Oregon] Agricultural Experiment Station. J. T. Jardine. 143 p. 1930.

The Pennsylvania Agricultural Experiment Station forty-third annual report for the fiscal year ending June 30, 1930. R. L. Watts et al. Pa. Sta. Bul. 258, 52 p., illus. 1930.

Report of the Porto Rico Agricultural Experiment Station, 1929. D. W. May et al. 29 p., illus. 1930.

Forty-second annual report of the director of the [Rhode Island] Agricultural Experiment Station, [1929]. B. E. Gilbert. p. 63–79. 1930.

Forty-third annual report of the director of the [Rhode Island] Agricultural Experiment Station, [1930]. B. E. Gilbert. p. 28–49. [1931.]

Forty-third annual report of the South Carolina Experiment Station of Clemson Agricultural College. H. W. Barre et al. 139 p., illus. 1930.

The South Carolina Agricultural Experiment Station, a brief history, 1887–1930. G. H. Aull. S. C. Sta. Circ. 44, 63 p., illus. 1930.

Annual report of the South Dakota Agricultural Experiment Station for the fiscal year ending June 30, 1930. J. W. Wilson. 35 p. [1930.]

Forty-second annual report [Tennessee Station], 1929. C. A. Mooers et al. 53 p. 1930.

Biennial report of Utah Agricultural Experiment Station, July 1, 1928, to June 30, 1930. P. V. Cardon. Utah Sta. Bul. 220, 63 p., illus. 1930.
Progress report, Carbon County Experimental Farm, 1927–30, inclusive. I. D. Zobell and G. Stewart. Utah Sta. Bul. 225, 20 p., illus. 1931.
Forty-third annual report, 1929–1930. J. L. Hills. Vt. Sta. Bul. 319, 24 p. 1930.
Fortieth annual report for the fiscal year ended June 30, 1930. E. C. Johnson et al. Wash. Col. Sta. Bul. 245, 77 p. 1930.
Annual report of the Western Washington Experiment Station for the fiscal year ending March 31, 1930. J. W. Kalkus et al. West. Wash. Sta. Bul. 18–W. 44 p., illus. 1930.
A year's service of research: Annual report of the director, 1929–1930. H. L. Russell et al. Wis. Sta. Bul. 420, 137 p., illus. 1931.
Fortieth annual report of the University of Wyoming Agricultural Experiment Station, 1929–1930. J. A. Hill. 52 p. [1930.]

PERIODICALS

Quarterly Bulletin, Michigan Agricultural Experiment Station.—vol. 13 (1930–1931), no. 1, 38 p., illus.; no. 2, p. 41–102, illus.; no. 3, p. 107–178, illus.; no. 4, p. 183–234, illus.
Bimonthly Bulletin. Ohio Sta. Bimo. Buls. 145, p. 97–128, illus.; 146, p. 129–175, illus.; 147, p. 179–208, illus.; 148, 32 p., illus.; 149, p. 34–80, illus.; 150, p. 83–119, illus. 1930–1931.
Current Farm Economics, Oklahoma Agricultural Experiment Station.—vol. 3 (1930), no. 2, 8 p.; no. 3, 8 p.; no. 4, 23 p., illus.; vol. 4 (1931), no. 1, 8 p., illus.; no. 2, 12 p., illus.; no. 3, 12 p., illus.

REGULATORY PUBLICATIONS, FERTILIZERS

Commercial fertilizers, report for 1930. E. M. Bailey. Conn. State Sta. Bul. 321, 108+xi p. 1930.
Commercial fertilizers. H. R. Kraybill et al. Ind. Sta. Circ. 171, 76 p., illus. 1930.
Analyses of commercial fertilizers. H. E. Curtis, H. R. Allen, and L. Gault. Ky. Sta. Bul. 298, p. 303–401. 1929.
Commercial fertilizers, 1930. J. M. Bartlett. Me. Sta. Off. Insp. 137, p. 37–64. 1930.
Inspection of commercial fertilizers. H. D. Haskins. Mass. Sta. Control Ser. Bul. 54, 64 p., illus. 1930.
Inspection of agricultural lime products. H. D. Haskins and H. R. DeRose. Mass. Sta. Control Ser. Bul. 57, 6 p. 1930.
Inspection and analysis of commercial fertilizers, spring, 1930. F. B. Mumford and L. D. Haigh. Mo. Sta. Bul. 292, 12 p. 1930.
Registration, labeling, inspection, and sale of commercial fertilizers, 1930. F. B. Mumford and L. D. Haigh. Mo. Sta. Bul. 298, 45 p. 1931.
Inspection of commercial fertilizers for 1930, made for the State Department of Agriculture. T. G. Phillips, T. O. Smith, and S. J. Fisher. N. H. Sta. Bul. 254, 14 p. 1930.
Analyses of commercial fertilizers, fertilizer supplies, and home mixtures for 1930. C. S. Cathcart. N. J. Stas. Bul. 514, 39 p. 1930.
Analyses of commercial fertilizers and ground bone; analyses of agricultural lime, 1930. C. S. Cathcart. N. J. Stas. Bul. 517, 29 p. 1931.
Fertilizer registrations for 1931. C. S. Cathcart. N. J. Stas. Bul. 518, 22 p. 1931.
Composition and cost of commercial fertilizers in New York from 1913 to 1930. A. W. Clark, W. F. Walsh, and F. J. Kokoski. N. Y. State Sta. Bul. 594, 19 p. 1931.
Commercial fertilizers, a report covering the biennium 1929–1930. J. S. Jones and C. F. Whitaker. Oreg. Sta. Circ. 98, 32 p. 1931.
Analyses of commercial fertilizers. R. N. Brackett and D. H. Henry. S. C. Sta. Bul. 267, 64 p. 1930.
Commercial fertilizers in 1929–1930 and their uses. G. S. Fraps and S. E. Asbury. Tex. Sta. Bul. 415, 50 p. 1930.
Commercial fertilizers. L. S. Walker and E. F. Boyce. Vt. Sta. Bul. 320, 24 p 1930.
A half century of fertilizer control in Ver mont. J. L. Hills. Vt. Sta. Bul. 323 40 p., illus. 1930.

REGULATORY PUBLICATIONS, FEEDING STUFFS

Report on inspection, commercial feeding stuffs, 1929. E. M. Bailey. Conn. State Sta. Bul. 317, p. 649–748+xix. 1930.
Commercial feeding stuffs, report on inspection, 1930. E. M. Bailey. Conn. State Sta. Bul. 325, p. 241–349+xx. 1931.
Commercial feeding stuffs. H. R. Kraybill et al. Ind. Sta. Circ. 170, 38 p. 1930.
Commercial feeds in Kentucky in 1929. J. D. Turner, H. D. Spears, W. G. Terrell, and L. V. Amburgey. Ky. Sta. Bul. 310, p. 509–546. 1930.
Commercial feeding stuffs, 1929–1930. J. M. Bartlett. Me. Sta. Off. Insp. 136, 36 p. 1930.
Inspection of commercial feedstuffs. P. H. Smith. Mass. Sta. Control Ser. Bul. 55, 44 p. 1930.
Inspection of commercial feeding stuffs, 1930, made for the State Department of Agriculture. T. G. Phillips, T. O. Smith, and J. C. Fritz. N. H. Sta. Bul. 253, 51 p. 1930.
Analyses of commercial feeding stuffs and registrations for 1930. C. S. Cathcart. N. J. Stas. Bul. 505, 93 p. 1930.
Inspection of feeds. W. L. Adams and A. S. Knowles, jr. R. I. Sta. Ann. Feed Circ., 12 p. 1931.
Commercial feeding stuffs, from September 1, 1929, to August 31, 1930. F. D. Fuller and S. D. Pearce. Tex. Sta. Bul. 420. 186 p. 1930.
The Texas feed law, revised regulations. F. D. Fuller. Tex. Sta. Circ. 58, 15 p. 1930.
Commercial feeding stuffs. L. S. Walker and E. F. Boyce. Vt. Sta. Bul. 309, 39 p. 1930.
Commercial feeding stuffs. L. S. Walker and E. F. Boyce. Vt. Sta. Bul. 321, 43 p. 1930.
A third of a century of feeding-stuff inspection. J. L. Hills. Vt. Sta. Bul. 324, 48 p., illus. 1930.

REGULATORY PUBLICATIONS, FOODS AND DRUGS

The thirty-fourth report on food products and the twenty-second report on drug products, 1929. E. M. Bailey. Conn. State Sta. Bul. 319, p. 773–824. 1930.
Foods and drugs. J. M. Bartlett. Me. Sta. Off. Insp. 135, 8 p. 1930.

REGULATORY PUBLICATIONS, SEEDS

Inspection of agricultural seeds. H. R. Kraybill et al. Ind. Sta. Circ. 177, 99 p., illus. 1930.
Commercial agricultural seeds, 1930; insecticides and fungicides, 1930. J. M. Bartlett et al. Me. Sta. Off. Insp. 138, p. 65–108. 1930.
Seed inspection. F. A. McLaughlin. Mass. Sta. Control Ser. Bul. 56, 42 p. 1930.
Results of seed tests for 1930, made for the State Department of Agriculture. B. I. Glidden. N. H. Sta. Bul. 252, 17 p. 1930.
Results of seed and legume inoculant inspection for 1930. J. G. Fiske. N. J. Stas. Bul. 516, 95 p. 1931.
Agricultural seed. A. S. Lutman. Fifteen years of agricultural seed inspection. J. L. Hills. Vt. Sta. Bul. 322, 20 p. 1930.

REGULATORY PUBLICATIONS, MISCELLANEOUS

Sixteenth annual report of the Creamery License Division for the year ending March 31, 1930. T. H. Binney. Ind. Sta. Circ. 176, 19 p., illus. 1930.
Creamery inspection in New Jersey, ninth annual report. H. H. Tucker. N. J. Stas. Bul. 508, 15 p., illus. 1930.
Analyses of materials sold as insecticides and fungicides during 1930. C. S. Cathcart and R. L. Willis. N. J. Stas. Bul. 513, 16 p. 1930.

PUBLICATION LISTS AND MISCELLANEOUS

Dedication of Atwater Laboratory, June 12, 1930. W. L. Slate et al. Conn. Storrs Sta. Bul. 168, p. 209–231, illus. 1930.
Information regarding recent publications. Kans. Sta. Circ. 157, 3 p. 1930.
Abstracts of papers not included in bulletins, finances, meteorology, index. Me. Sta. Bul. 353, p. 139–156; contents, etc., of report, 1929, xiii p. 1929.
Bulletins and circulars available at the experiment station. N. Y. State Sta. Circ. 116, 6 p., illus. 1930.
List and analytical index of publications of the Porto Rico Agricultural Experiment Station (July, 1900, to March, 1930). E. H. Langdale. Porto Rico Sta. Circ. 21, 42 p. 1930.
Abstracts of Bulletins 405–420 and Circulars 55–58. A. D. Jackson. Tex. Sta. Circ. 59, 31 p. 1930.
Annual summary of publications. B. C. Pittman. Utah Sta. Circ. 88, 11 p. 1930.
Classified list of available publications, March, 1929. Vt. Sta. Circ. 14, 4 p. [1929.]

PERSONNEL CHANGES

Changes in the directorships of the stations for the year ended June 30, 1931, included two resignations and one death. Of the other major changes in staff personnel, 43 were among the leaders or heads of departments and 96 in the rank of associate, and included 11 deaths.

CHANGES IN DIRECTORSHIPS

W. J. Morse, director of the Maine station for the last 10 years, died March 25, 1931, and was succeeded by Fred Griffee, the assistant director. In Louisiana, C. T. Dowell relinquished the duties of dean of the college of agriculture to devote his time exclusively to the directorship of the experiment station. W. R. Perkins, assistant director of the South Mississippi branch station, succeeded J. R. Ricks as director of the Mississippi station, assuming his duties September 1, 1930. C. L. Christensen, secretary of the Federal Farm Board, was elected director of the Wisconsin station, succeeding H. L. Russell, resigned.

OTHER CHANGES

Appointments at the Alabama station included M. W. Emmel, animal pathologist; G. A. Schrader, research associate in animal nutrition; Edna R. Bishop, research home economist, vice Anna L. Sommer, transferred to the department of agronomy; and L. M. Ware, succeeding W. D. Kimbrough as associate horticulturist. J. L. Seal was designated acting head of the department of botany and plant pathology, vice W. A. Gardner. N. B. Guerrant, associate in animal nutrition, resigned.

E. L. Scott was appointed associate in animal husbandry at the Arizona station, effective in July, 1930. D. W. Albert, associate horticulturist, was transferred to full-time station work and placed in charge of the horticultural investigations in the Salt River Valley.

Resignations at the Arkansas station included those of Mrs. Henrietta K. Burton, head of the home economics department, and R. P. Holdsworth, forester.

J. M. Tinley and G. M. Peterson were appointed associate agricultural economists at the California station for the work of the Giannini Foundation. Other appointments in the rank of associate included those of Walter Bauer and L. A. Crawford in agricultural economics, H. D. Lewis in agricultural engineering, C. F. Poole in genetics, S. L. Emsweller in truck crops, and C. J. Parshall in veterinary science. W. A. Lippincott, head of the poultry division, died on January 5, 1931, and A. H. Hoffman, agricultural engineer, died on May 19, 1931.

F. E. Goetz was appointed research engineer at the Colorado station. Florence N. Schott, associate in home economics, and J. W. Adams, superintendent of the Cheyenne Wells substation, resigned.

Erwin Jungherr of Texas was appointed animal pathologist at the Connecticut (Storrs) station, and C. D.

Clark, research associate in sociology, resigned.

H. H. Hume, a former member of the horticultural staff, was selected to be assistant director of research for the Florida station, assuming his duties March 1, 1931. H. S. Wolfe was appointed associate horticulturist at the subtropical station at Homestead, effective September 1, 1930, and in March, 1931. was placed in charge of the administrative work. New appointments at the Everglades substation included those of J. R. Neller, associate biochemist; R. N. Lobdell, associate entomologist; B. A. Bourne, associate plant physiologist in sugarcane investigations; and Adrian Daane, associate agronomist.

The Georgia station reported the appointment of Brim Jarrett as superintendent of the new substation at Blairsville. Elma S. Jones was appointed specialist in rural sociology.

M. R. Kulp was appointed irrigationist at the Idaho station.

Sybil Woodruff was added to the Illinois station staff as assistant chief in foods in the division of home economics. Resignations reported included those of M. B. Harland, associate in soil physics, and D. A. Milligan, associate in farm mechanics.

R. M. Caldwell succeeded E. B. Mains as associate in botany at the Indiana station, assuming his duties in September, 1930. Miriam Rapp, research economist, and L. H. Schwartz, associate in poultry husbandry, resigned.

In a reorganization of the animal husbandry department at the Iowa station, effective January 1, 1931, C. C. Culbertson was selected as chief of beef-cattle, swine, and sheep production, B. H. Thomas assumed the duties of chief in animal chemistry and nutrition, and D. L. Espe was made assistant chief in dairy husbandry. Upon return from a year's leave spent with the Bureau of Public Roads of the United States Department of Agriculture, Henry Giese was made assistant chief of the agricultural engineering section of the station. L. H. Pammel, botanist at the station since 1889, died March 23, 1931.

At the Kansas station H. E. Reed, animal husbandman, was placed in charge of the beef-cattle investigations, succeeding B. M. Anderson; later he resigned to accept a position in the Department of Agriculture, and R. F. Cox of the New Mexico station was appointed to handle investigations with sheep. F. J. Zink succeeded R. H. Driftmier as associate in agricultural engineering, and George Montgomery of the extension service was transferred to the station for marketing investigations vice W. P. Mortenson, resigned. S. C. Salmon of the department of agronomy resigned June 30, 1931, to accept a position in the Department of Agriculture, and was to be succeeded by H. H. Laude, whose position in charge of the cooperative experimental work at the station was to be assumed by A. L. Clapp of the extension service. Margaret S. Chaney, home economist, resigned. Albert Dickens, horticulturist since 1902, died November 28, 1930.

The Kentucky station reported the resignation of C. H. Burrage, forester at the Robinson substation.

W. D. Kimbrough was appointed associate in horticultural research at the Louisiana station for investigations in vegetable crops, and Harry Smith was made investigator in poultry husbandry.

W. F. Dove, associate biologist at the Maine station, was made head of the department of biology. J. A. Chucka was added to the staff as associate biologist in plant nutrition and R. M. Bailey as associate biologist in charge of the investigations in horticulture at the Highmoor farm.

P. D. Sanders of the extension service was added to the Maryland station staff as associate entomologist, and Roland Bamford as botanist to specialize in cytological investigations.

W. S. Eisenmenger was appointed research professor of agronomy at the Massachusetts station, and C. H. Parsons was made farm superintendent. R. M. Koon of the extension service was placed in charge of the Waltham field station.

C. E. Millar, research associate in soils at the Michigan station, succeeded M. M. McCool as head of the department, assuming his new duties in July, 1930. P. A. Herbert of the United States Forest Service was chosen head of the department of forestry to fill the vacancy caused by the death of A. K. Chittenden on November 1, 1930. Other appointments included Ray Hutson, research associate in entomology, and C. H. Mahoney, who succeeded G. E. Starr as research associate in horticulture.

W. A. Riley of the University of Minnesota succeeded R. N. Chapman as chief of the division of entomology and economic zoology at the Minnesota station. C. E. Lively of Ohio was added to the staff as associate in rural

economics, and A. A. Granovsky, of the teaching faculty, was assigned to part-time station work in entomology. H. E. Brewbaker and J. F. Stevenson, plant geneticists, resigned.

The Mississippi station reported a number of changes in staff, all effective in September, 1930. C. B. Cain, veterinarian of the station, succeeded D. S. Buchanan as head of the animal husbandry department; H. D. Bradshaw was appointed head of the department of bacteriology vice C. F. Briscoe, who relinquished administrative duties for research exclusively, and T. N. Jones, agricultural engineer, succeeded J. W. Carpenter, jr. R. V. Lott of Colorado was selected to head the department of horticulture vice J. C. C. Price, and L. M. Ware, horticulturist, resigned to return to his former position at the Alabama station. C. E. O'Neal and G. B. Bradshaw were appointed veterinarians; T. F. McGehee succeeded C. T. Ames as assistant director of the Holly Springs branch station; and J. C. Robert assumed similar duties at the South Mississippi branch station. L. M. Cooley, jr., was transferred from the South Mississippi to the Natchez branch station for work in horticulture.

L. D. Baver of Alabama was placed in charge of soils research at the Missouri station. C. G. Vinson was added to the staff as horticulturist, and A. M. McCapes of Oregon, as special investigator in contagious abortion. I. T. Scott, plant pathologist, resigned.

Louis Vinke, associate animal husbandman at the Montana station, succeeded H. W. Vaughan as head of the department of animal husbandry, assuming his new duties in the fall of 1930. A. L. Strand came from Minnesota as head of the department of entomology vice R. A. Cooley, resigned, and R. E. Wall succeeded W. C. Cook as associate entomologist. A. H. Post, associate agronomist, was designated acting head of the agronomy department during the absence of Clyde McKee.

J. O. Rankin, associate in rural economics at the Nebraska station, resigned in the spring of 1931.

F. G. Helyar relinquished his position as animal husbandman at the New Jersey State station to devote his time exclusively to administrative duties in resident teaching. He was succeeded at the station by his associate, W. C. Skelley. Florence T. Starkey was added to the staff as acting research associate in bacteriology. C. B. Howe, research associate in agricultural economics, resigned to take a position with the Federal Farm Board.

D. C. Carpenter, chief in research in chemistry at the New York State station, was made head of the division vice J. J. Willaman, who resigned in October, 1930. L. R. Streeter, associate in research, was promoted to be chief in chemistry, and Z. I. Kertesz, from assistant to associate in research in chemistry. H. S. Cunningham succeeded E. E. Clayton as associate in research in plant pathology, and assigned to the work at the Long Island vegetable research farm, assuming his duties June 1, 1931.

The North Carolina station announced that R. S. Dearstyne, associate in poultry science, had been chosen to succeed B. F. Kaupp as head of the department. I. D. Jones of the Minnesota college was appointed associate horticulturist at this station.

E. J. Thompson, animal husbandman at the North Dakota station, assumed the duties of chairman of the department, succeeding J. H. Shepperd, who was elected president of the college. H. C. Hanson of Colorado was appointed station botanist, effective July 1, 1930. A. F. Schalk, veterinarian, resigned to accept the chairmanship of the department of preventive medicine at Ohio State University, and L. M. Roderick, his assistant, was designated acting head of the department. G. J. Baker returned to the extension service after serving two years as animal husbandman for the station. R. C. Miller, agricultural engineer, resigned and H. F. McColly was placed in charge of the work, pending appointment of a successor.

B. E. Leete, associate forester at the Ohio station, died in April, 1931.

L. S. Ellis was added to the Oklahoma station staff to take charge of investigations in agricultural prices, and Mrs. Callie M. Coons, of the department of home economics of the college, was transferred to full-time research in human nutrition. O. W. Herrmann, associate in agricultural marketing, resigned to accept a position with the Federal Farm Board. F. P. Sanmann, associate in dairy manufacturing, died July 5, 1930.

B. F. Dana of Texas was added to the Oregon station staff as plant pathologist. E. M. Harvey, research horticulturist, resigned in June, 1931, to take a position in the Department of Agriculture.

J. A. Sperry was appointed bacteriologist at the Pennsylvania station. H. B. Josephson, research professor of farm machinery, met death by

drowning while on leave in Germany. The Institute of Animal Nutrition of the station reported additions to the staff of D. E. Frear and F. J. McClure, associates in animal nutrition, and the resignation of R. B. French, an associate.

The South Carolina station announced the selection of H. P. Cooper of Cornell University as head of the department of agronomy. C. H. Arndt was added to the staff as associate plant pathologist.

S. E. Johnson, agricultural economist at the South Dakota station, succeeded M. R. Benedict as head of the agricultural economics department, and W. C. Tully was appointed poultry husbandman vice G. L. Stevenson, resigned.

S. H. Yarnell was transferred from the Winter Haven, Tex., substation to the Texas station to be chief of the division of horticulture, a position left vacant by the resignation of H. P. Traub. L. R. Hawthorn, of Geneva, N. Y., succeeded as horticulturist at the Winter Haven substation. W. T. Hardy was added to the main station staff as veterinarian.

The Utah station announced the selection of E. J. Maynard, of Colorado, as head of the department of animal husbandry to succeed K. C. Ikeler. R. J. Evans, a former director of the extension service, was appointed head of the department of agronomy vice George Stewart, who resigned to become associated with the United States Forest Service. A. L. Wilson, formerly superintendent of the Davis County substation, was added to the main station staff as associate horticulturist, assuming duties in April, 1931.

Effective July 1, 1930, H. P. Young, agricultural economist at the Vermont station, returned to the extension service, but continued to give part of his time to station work. J. A. Hitchcock, associate economist, resigned September 1, 1930, to take graduate work at Cornell University.

The Virginia station reported several changes in personnel. S. A. Wingard, acting head of the department of botany and plant pathology, was made head of the department. R. A. Runnells, associate animal pathologist, resigned. C. C. Taylor, agricultural economist, resigned in November, 1930, to become agricultural attaché at Cape Town, South Africa, and H. N. Young, his associate, was designated acting head of the department of agricultural economics. P. B. Potter of the teaching faculty was added to the station staff as associate agricultural engineer, and G. W. Patteson was appointed agronomist in soil survey work.

The Virginia truck station announced the appointment of H. G. Walker as entomologist, effective February 15, 1931.

Death claimed two members of the Washington station staff, George Severance, head of the division of farm management and agricultural economics, dying on March 8, and H. F. Holtz, associate in soils, on April 20, 1931. L. A. Black, associate dairy bacteriologist, resigned. R. E. Hodgson, of Kansas, was appointed dairy husbandman at the Western Washington station.

Horace Atwood, head of the poultry work at the West Virginia station for 34 years, retired in June, 1931. The University of West Virginia conferred upon him the honorary title of professor emeritus of poultry husbandry.

James Waddell, research associate in agricultural chemistry at the Wisconsin station, resigned.

MARY A. AGNEW.

INCOME, EXPENDITURES, AND OTHER STATISTICS, 1931

By J. I. Schulte

The following tables give detailed data regarding (1) personnel, publications, and mailing lists of the experiment stations; (2) revenues and additions to equipment; (3) expenditures from the Hatch, Adams, and Purnell funds; (4) expenditures from the supplementary funds; and (5) total disbursements from the United States Treasury under the Hatch, Adams, and Purnell Acts from their passage to the end of the fiscal year, June 30, 1931.

Table 3.—*Personnel, publications, and mailing lists of the experiment stations, 1931*

Station	Date of original organization	Date of organization under Hatch Act	Persons on staff	Teachers on staff	Persons on staff assisting in extension work	Publications during fiscal year		Names on mailing list
						Number	Pages	
Alabama	February, 1883	Feb. 24, 1888	54	26		8	184	3,000
Alaska	——, 1898		6			2	73	533
Arizona		——, 1889	38	30		9	248	4,800
Arkansas		——, 1887	47	35		12	760	5,500
California	——, 1875	March, 1888	205	98	130	63	2,970	3,510
Colorado		Feb. 29, 1888	70	40	12	20	862	900
Connecticut (State)	Oct. 1, 1875	May 18, 1887	46			18	1,450	16,627
Connecticut (Storrs)		May 18, 1887	35	13	5	10	293	10,973
Delaware		Feb. 21, 1888	22	7	5	6	273	7,000
Florida		——, 1888	75	2	4	21	1,512	12,000
Georgia	Feb. 18, 1888	July 1, 1889	28			11	238	7,000
Guam	——, 1909		6			1	20	
Hawaii	——, 1901		12	5		3	93	650
Idaho		Feb. 26, 1892	48	26	12	18	480	15,658
Illinois		Mar. 21, 1888	142	84	14	40	1,796	19,165
Indiana	——, 1885	January, 1888	111	27		52	1,743	38,510
Iowa		Feb. 17, 1888	112	55	4	37	1,304	14,291
Kansas		Feb. 8, 1888	107	80		9	626	13,900
Kentucky	September, 1885	April, 1888	76	22	6	12	564	16,000
Louisiana	April, 1886		48	6		14	501	4,770
Maine	March, 1885	Oct. 1, 1887	29	3	3	9	363	17,400
Maryland	——, 1888	April, 1888	47	22	8	9	500	32,100
Massachusetts	——, 1882	Mar. 2, 1888	71	16		44	682	15,000
Michigan		Feb. 26, 1888	117	55	6	29	1,480	16,000
Minnesota	Mar. 7, 1885	——, 1888	142	94	10	51	1,175	37,000
Mississippi		Jan. 27, 1888	56	17		21	540	15,000
Missouri		January, 1888	88	67	1	29	1,320	4,980
Montana		July 1, 1893	48	17	6	18	682	4,776
Nebraska	Dec. 16, 1884	June 13, 1887	43	28		25	813	1,316
Nevada		December, 1887	21	2		5	130	5,000
New Hampshire	——, 1886	Aug. 4, 1887	45	21	7	19	380	8,000
New Jersey (State)	Mar. 10, 1880		[1] 91	18	34	98	2,608	27,000
New Jersey (College)		Apr. 26, 1888	37					
New Mexico		Dec. 14, 1889	29	17	8	51	409	10,000
New York (Cornell)	——, 1879	April, 1888	107	81	2	26	1,675	82,082
New York (State)	March, 1882		62			37	1,033	10,000
North Carolina	Mar. 12, 1877	Mar. 7, 1887	48	17	2	21	1,717	8,685
North Dakota		March, 1890	53	20	2	15	610	8,400
Ohio	Apr. 25, 1882	Apr. 2, 1888	131	34	2	50	2,106	61,114
Oklahoma		Oct. 27, 1890	58	42		11	604	5,000
Oregon		July, 1888	84	39		36	951	1,800
Pennsylvania		June 30, 1887	120	109		25	512	29,850
Puerto Rico	——, 1901		6		1	3	87	1,272
Rhode Island		July 30, 1888	22	3	3	14	206	6,000
South Carolina		January, 1888	42	11	2	17	754	7,000
South Dakota		Mar. 13, 1887	32	28	2	11	420	5,000
Tennessee	June 8, 1887	Aug. 4, 1887	35	5		26	251	13,755
Texas		Apr. 3, 1889	98	1		21	1,041	15,000
Utah		——, 1890	43	27	6	18	506	10,000
Vermont	Nov. 24, 1886	Feb. 28, 1888	29	15	1	10	365	4,000
Virginia	——, 1888	——, 1891	50	17	8	5	179	12,000
Virgin Islands	——, 1920		4		1	1	19	632
Washington		——, 1891	52	24		14	570	17,864
West Virginia		June 11, 1888	52	26	5	10	451	12,000
Wisconsin	——, 1883	——, 1887	119	80	64	15	620	46,538
Wyoming		Mar. 1, 1891	40	22	2	12	317	8,000
Total			3,419	1,534	378	1,172	42,066	754,351

[1] Including 20 also on college station staff, not included in total.

TABLE 4.—*Revenues and expenditures*

Station	Revenues						
	Federal			State	Balance from previous year [1]	Fees	Sales
	Hatch fund	Adams fund	Purnell fund				
Alabama	$15,000	$15,000	$60,000	$201,822.94	$44,110.16		$13,180.05
Alaska [2]							
Arizona	15,000	15,000	60,000	106,512.50	1,130.36		2,432.13
Arkansas	15,000	15,000	60,000	120,045.50			18,488.16
California	15,000	15,000	60,000	915,627.15	27,570.44	$7,340.45	80,422.03
Colorado	15,000	15,000	60,000	104,506.69	35,149.53		29,045.89
Connecticut (State)	7,500	7,500	30,000	217,187.43	3,043.59	23,000.00	
Connecticut (Storrs)	7,500	7,500	30,000	42,381.64	6,423.48	11,669.92	4,370.02
Delaware	15,000	15,000	60,000	18,500.00	5,691.73		16,908.59
Florida	15,000	15,000	60,000	401,895.00	75,484.52		20,169.14
Georgia	15,000	15,000	60,000	16,475.51	11,170.10		10,474.23
Guam [2]							
Hawaii [2]	15,000	5,000			21,933.91		19,961.07
Idaho	15,000	15,000	60,000	49,149.85	1,518.55		2,261.91
Illinois	15,000	15,000	60,000	440,867.57			76,883.79
Indiana	15,000	15,000	60,000	303,842.09	162,666.55	130,136.82	66,268.55
Iowa	15,000	15,000	60,000	245,000.00	29,141.30		28,721.63
Kansas	15,000	15,000	50,000	115,750.00	14,962.56	66,660.94	
Kentucky	15,000	15,000	60,000	174,216.05	35,691.91	137,165.14	39,861.27
Louisiana	15,000	15,000	60,000	100,000.00	28,695.26	27,739.90	22,732.19
Maine	15,000	15,000	60,000	35,000.00	15,881.39	12,000.00	17,223.65
Maryland	15,000	15,000	60,000	75,239.19	3,796.89		24,969.07
Massachusetts	15,000	15,000	60,000	187,821.06		77,956.43	15,402.69
Michigan	15,000	15,000	60,000	342,230.34			29,818.06
Minnesota	15,000	15,000	60,000	295,663.62		734.01	95,830.14
Mississippi	15,000	15,000	60,000	141,544.80	5,673.80		19,708.27
Missouri	15,000	15,000	60,000	44,491.94	40,106.89	28,249.45	38,848.45
Montana	15,000	15,000	60,000	109,362.84	9,131.78		29,745.36
Nebraska	15,000	15,000	60,000	189,334.98			51,534.45
Nevada	15,000	15,000	60,000	2,283.34	2,310.80		4,070.14
New Hampshire	15,000	15,000	60,000	5,800.00	10,084.26		2,741.46
New Jersey (State)				798,315.00		52,532.01	40,331.74
New Jersey (College)	15,000	15,000	60,000				
New Mexico	15,000	15,000	60,000	13,000.00	9,157.10		39,164.10
New York (State)	1,500	1,500	6,000	378,913.37	9,375.62		12,765.60
New York (Cornell)	13,500	13,500	54,000	765,565.17		30,000.00	35,792.60
North Carolina	15,000	15,000	60,000	127,409.36	4,004,66		53,065.30
North Dakota	15,000	15,000	60,000	134,453.50	21,902.55		61,602.58
Ohio	15,000	15,000	60,000	371,795.00	584,069.40		90,344.32
Oklahoma	15,000	15,000	60,000	107,690.34	21,123.00		19,989.32
Oregon	15,000	15,000	60,000	93,675.28	134,019.18	3,565.11	55,343.97
Pennsylvania	15,000	15,000	60,000	120,163.23	268.44		43,065.62
Puerto Rico [2]							
Rhode Island	15,000	15,000	60,000		42.20		6,854.35
South Carolina	15,000	15,000	60,000	68,631.36			59,777.43
South Dakota	15,000	15,000	60,000	29,851.75	11,070.65		11,747.28
Tennessee	15,000	15,000	60,000	43,941.58	1,879.30		18,182.57
Texas	15,000	15,000	60,000	361,266.00	61,422.45		94,406.99
Utah	15,000	15,000	60,000	89,100.45			12,296.58
Vermont	15,000	15,000	60,000		132,11	21,705.05	2,360.70
Virginia	15,000	15,000	60,000	108,970.00	10,093.47		8,975.81
Virgin Islands [2]							
Washington	15,000	15,000	60,000	85,390.79	28,459.15		35,152.25
West Virginia	15,000	15,000	60,000	93,500.00	2,314.57		45,711.08
Wisconsin	15,000	15,000	60,000	310,266.91			65,223.65
Wyoming	15,000	15,000	60,000	62,103.07	11,535.82		23,993.41
Total	735,000	725,000	2,880,000	9,166,554.19	1,502,239.43	630,455.23	1,618,219.64

[1] Not including balances from Federal funds.
[2] Support from direct appropriations to the U. S. Department of Agriculture given under "Miscellaneous."

for additions to equipment, 1931

Revenues—Continued		Additions to equipment						
Miscellaneous	Total	Buildings	Library	Apparatus	Farm implements	Livestock	Miscellaneous	Total
----------	$349,113.15	$21,406.69	$1,418.15	$5,154.63	$14,122.99	$1,232.24	----------	$43,334.70
$85,300.00	85,300.00	----------	----------	----------	----------	----------	----------	----------
----------	200,074.99	11,332.38	----------	5,524.68	1,929.40	1,200.00	$1,515.62	21,502.08
----------	228,533.66	4,800.61	851.09	12,423.97	1,344.08	813.36	4,079.80	24,312.91
49,780.35	1,170,740.42	103,073.84	11,300.00	16,018.95	16,018.95	16,018.96	----------	162,430.70
4,670.00	263,372.11	3,886.00	882.00	3,860.00	3,704.00	3,860.00	447.00	16,639.00
7,634.17	295,865.19	2,594.50	1,708.41	2,272.00	3,780.81	----------	2,134.11	12,489.83
350.00	110,195.06	1,205.47	924.11	2,823.03	162.51	----------	623.46	5,738.58
----------	131,100.32	4,012.47	1,094.47	3,027.71	2,388.89	----------	----------	10,523.54
----------	587,548.66	59,217.39	5,388.90	20,199.51	10,915.49	2,772.63	12,509.18	111,003.10
----------	128,119.84	2,000.00	1,000.00	2,000.00	1,008.90	610.50	1,500.00	8,119.40
30,200.00	30,200.00	----------	----------	----------	----------	----------	----------	----------
45,200.00	107,094.98	----------	----------	----------	----------	----------	----------	----------
----------	142,930.31	14,500.00	600.00	3,500.00	2,500.00	1,500.00	500.00	23,100.00
13,304.46	621,055.82	9,760.60	3,920.04	3,920.04	3,920.04	3,920.04	3,920.04	29,360.80
96,272.88	849,186.89	34,153.59	2,462.18	11,958.85	2,573.79	3,086.00	16,028.75	70,263.16
----------	392,862.93	----------	----------	6,330.79	422.00	3,608.30	----------	10,361.09
----------	287,373.50	22,160.14	310.32	1,159.23	15,510.62	3,023.50	2,585.04	44,748.85
13,503.33	490,437.70	31,986.78	272.00	2,602.63	----------	2,074.24	7,215.25	44,150.90
7,961.57	277,128.92	831.76	13.50	1,475.46	1,820.43	585.10	----------	4,726.25
7,000.00	177,105.04	29,910.44	1,265.03	10,501.37	1,987.61	----------	2,370.00	46,034.45
28,367.71	222,372.86	2,450.22	508.12	4,430.90	4,349.11	1,628.15	765.85	14,132.35
10,360.11	381,540.29	8,787.01	750.00	6,092.61	3,933.59	----------	3,350.09	22,913.30
----------	462,048.40	21,642.00	1,671.00	6,082.00	1,301.00	255.00	4,446.00	35,397.00
13,093.41	495,321.18	20,913.90	2,484.69	1,834.84	11,898.81	6,238.69	1,599.51	44,970.44
3,763.29	260,690.16	56,095.00	164.30	3,151.82	1,351.33	----------	1,758.16	62,520.61
24,365.25	266,061.98	1,123.82	672.04	8,605.85	5,369.25	8,967.69	1,473.88	26,212.53
----------	238,239.98	2,910.96	944.43	2,160.99	4,260.95	2,325.65	2,286.27	14,889.25
----------	330,869.43	19,714.81	189.26	5,898.31	6,687.57	18,690.00	1,166.53	52,346.48
----------	98,664.28	1,010.56	92.14	727.55	201.13	415.00	325.00	2,771.38
37,143.73	145,769.45	1,735.11	765.00	4,388.70	2,092.22	55.40	387.19	9,423.62
3,000.00	894,178.75	280,000.00	2,586.29	14,538.60	795.01	17,435.60	3,461.34	318,816.84
----------	90,000.00	1,267.76	312.45	2,617.35	1,057.92	66.40	223.50	5,545.38
----------	151,321.20	94,500.00	282.28	380.75	3,099.90	----------	1,607.04	99,869.97
----------	410,054.59	----------	2,541.40	2,450.00	1,652.71	75.00	156,361.19	163,080.30
8,793.14	921,149.91	178,955.12	2,776.58	119,849.27	10,869.48	864.59	22,099.13	335,414.17
2,932.84	277,412.16	10,000.00	595.76	393.83	6,245.54	3,867.20	4,000.00	25,102.33
3,547.66	311,506.28	11,276.30	718.33	1,650.66	6,869.69	6,962.00	1,121.26	28,598.24
5,704.76	1,141,913.48	92,445.22	1,714.30	4,514.27	9,179.24	9,952.60	2,477.81	120,283.44
44,343.10	283,145.76	23,756.79	1,287.10	7,602.67	589.18	2,500.00	6,027.61	41,763.35
6,500.00	383,103.54	----------	27.47	1,114.20	8,868.33	655.00	6,536.66	17,201.66
----------	253,497.29	----------	38.50	2,184.66	1,695.94	----------	1,908.48	5,827.58
59,200.00	59,200.00	----------	----------	----------	----------	----------	----------	----------
----------	96,896.55	7,650.00	850.00	557.00	1,057.00	5.00	1,075.00	11,194.00
----------	218,408.79	5,653.77	258.26	1,579.05	2,263.93	4,982.00	1,039.80	15,776.81
4,124.94	146,794.62	----------	120.00	2,000.00	1,200.00	----------	----------	3,320.00
2,500.00	156,503.45	3,281.00	881.20	1,512.49	----------	131.75	500.46	6,306.90
72,567.60	679,663.04	28,973.89	1,951.60	4,492.76	18,933.46	4,629.05	3,120.64	62,101.40
500.00	191,897.03	1,458.70	435.73	4,837.08	277.00	135.00	1,291.50	8,435.01
----------	114,197.86	----------	393.45	2,172.29	6,466.12	32.25	1,210.41	10,274.52
----------	218,039.28	1,745.05	988.47	1,940.42	788.47	3,000.00	1,272.09	9,734.50
30,300.00	30,300.00	----------	----------	----------	----------	----------	----------	----------
2,275.00	241,277.19	8,879.39	2,892.66	3,641.21	3,000.54	544.30	2,021.85	20,979.95
----------	231,525.65	19,197.22	44.95	3,345.58	2,500.59	5,489.94	2,150.01	32,728.29
74,255.28	539,745.84	209,255.00	1,424.69	5,839.54	3,752.63	4,192.61	3,263.47	227,727.94
----------	187,632.30	6,641.37	450.00	3,507.42	7,427.68	2,792.42	----------	20,818.89
798,813.58	18,056,282.07	1,478,152.63	65,222.65	350,847.52	224,145.83	151,193.16	295,755.98	2,565,317.77

TABLE 5.—*Expenditures from United States appropriations received under*

Station	Amount of appropriation	Classified expenditures						
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies
Alabama	$15,000	$10,155.01	$2,449.27	$426.25	$304.71	$51.52		$15.31
Arizona	15,000	14,999.76			.24			
Arkansas	15,000	6,815.00	3,148.93	1,871.06	120.33	61.79	$74.15	374.09
California	15,000	15,000.00						
Colorado	15,000	15,000.00						
Connecticut (State)	7,500	7,500.00						
Connecticut (Storrs)	7,500	7,500.00						
Delaware	15,000	8,602.85	1,870.71	533.88	1,108.52	41.10	533.72	93.52
Florida	15,000	15,000.00						
Georgia	15,000	7,907.31	2,142.84	826.36	729.71	155.34	613.79	58.02
Hawaii	15,000	6,864.29	4,339.22		47.53	56.33		127.06
Idaho	15,000	9,036.55	3,063.39	731.18	213.67	26.93	19.95	2.65
Illinois	15,000	14,883.30	116.70					
Indiana	15,000	15,000.00						
Iowa	15,000	8,115.00	802.56	1,137.55	88.76	40.00	85.19	400.11
Kansas	15,000	9,700.00	4,597.26		29.54		4.25	25.68
Kentucky	15,000	14,854.82		61.60				
Louisiana	15,000	7,321.67	4,483.43	1,202.06	123.31		214.43	37.42
Maine	15,000	8,321.30	2,288.00		78.20	69.00	1,416.68	
Maryland	15,000	14,473.33	132.50	171.96	44.02		5.03	57.61
Massachusetts	15,000	14,672.68						
Michigan	15,000	15,000.00						
Minnesota	15,000	15,000.00						
Mississippi	15,000	11,179.88	1,081.25		95.29	90.26	522.80	
Missouri	15,000	9,206.70	2,463.41	15.50	387.54	187.96	45.79	83.41
Montana	15,000	8,570.76	2,583.93	735.74	689.36	32.53	20.00	317.15
Nebraska	15,000	15,000.00						
Nevada	15,000	9,755.00	1,704.10	299.40	485.79	1.39	289.38	55.90
New Hampshire	15,000	9,672.70	638.52	592.04	756.20	329.54	700.00	24.64
New Jersey	15,000	9,020.00	1,368.41	57.65	557.59		44.90	175.18
New Mexico	15,000	8,858.78	2,746.31	1,301.25	144.68	105.29	296.88	69.72
New York (Cornell)	13,500	8,227.00	3,819.59		129.70	17.99	.15	506.50
New York (State)	1,500	1,500.00						
North Carolina	15,000	13,063.00	351.96		37.02	24.25		210.19
North Dakota	15,000	15,000.00						
Ohio	15,000	8,505.01	3,021.67	543.12	36.79			139.50
Oklahoma	15,000	4,478.71	4,774.70	1,170.32	190.80	17.81	22.13	191.11
Oregon	15,000	10,400.00	2,223.52	1,088.80	233.76	5.40	142.85	69.24
Pennsylvania	15,000	12,678.34	711.30	1,382.45	29.36			
Rhode Island	15,000	5,061.27	4,973.58	1,045.88	228.68	167.10	90.38	84.59
South Carolina	15,000	8,961.43	1,082.07	1,050.57	664.55	81.97	12.90	170.60
South Dakota	15,000	6,584.63	5,056.45	2,456.58	86.21	35.93	10.88	186.94
Tennessee	15,000	10,264.33	1,803.87	706.89	445.94	37.71	581.98	.30
Texas	15,000	14,482.46	367.92		2.42	1.61		48.04
Utah	15,000	10,150.33	2,151.26	172.56	106.22	58.25	64.00	228.09
Vermont	15,000	9,176.78	1,346.58	1,822.88	327.49	17.95	828.73	120.53
Virginia	15,000	8,617.48	4,587.10		471.81	34.48	107.74	261.10
Washington	15,000	10,546.08	1,654.38	1,781.75	14.54			201.22
West Virginia	15,000	4,875.00	3,233.33		43.81	6.56	55.82	1,180.16
Wisconsin	15,000	14,100.00	900.00					
Wyoming	15,000	7,586.13	6,150.13		31.56	18.32	90.65	167.27
Total	735,000	527,304.67	90,230.15	23,185.32	9,085.65	1,774.31	8,895.15	5,682.85

the act of March 2, 1887 (Hatch Act), for the year ended June 30, 1931

Classified expenditures—Continued

Seeds, plants, and sundry supplies	Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land
$100.24	$142.97	$698.84	$419.70		$146.74			$89.44		
642.13	213.06	720.90		$121.38	357.46	$432.41	$25.55	11.76	$10.00	
406.69	190.07		662.33	257.40	252.94	9.92		413.40	22.95	
554.72	110.92	3.30	810.41	347.96	263.01	105.18		327.70		$43.43
116.36	2.00	1,408.01	5.50	201.22	237.10	1,128.71	100.00	366.67		
313.40		397.78		157.45	49.80			894.34		32.91
798.88	76.00	3,314.88		65.35	1.50	39.77		34.45		
56.60			6.76	78.91	51.12	16.06		413.57		20.25
								83.58		
395.75		33.00		382.84	28.80			30.88		746.41
		1,485.81	739.58		407.90			193.53		
.25								115.30		
								327.32		
503.78		501.82	20.00	741.34				237.48	21.90	4.20
163.39		466.71	219.11	166.60	172.27	439.57		444.49		537.55
235.40		605.25	369.00	197.47	542.96	5.68		94.77		
416.16		441.90	48.96	270.01	119.76		1.50	824.65	69.25	216.81
149.69	104.83		600.27	393.86	7.48	395.66		621.37	13.20	
211.82	153.80	365.85	163.43	399.97	157.77	928.26		1,036.42	103.31	255.64
319.60	119.92		19.28	529.91	43.65	67.74		243.82		133.17
151.42	124.31		1.62	7.53	145.99	168.72		199.48		
136.97	39.18				55.00	131.74		950.69		
357.94		1,980.07		25.75	35.25	33.00				321.90
1,287.18		980.47	2.75	387.01	93.79	280.87	206.47	851.28		64.60
105.49	8.39			167.68	70.26			460.31	24.30	
	198.55									
700.81	368.28	247.95	292.02	615.05	131.20	21.96		234.88		736.37
586.92	218.57	362.27	690.49	424.28	95.25	57.90		335.51	26.05	178.67
243.81	5.64	112.30		173.13	47.50					
168.33	40.34		574.02	73.76	74.58			219.78	5.27	2.90
24.22		41.80	13.08	2.25		5.00	11.20			
305.92		825.89	23.20	194.41	137.00	132.28	5.00	415.19		30.40
252.39	76.73		210.36	128.78	88.04	154.88		243.86	72.77	131.25
195.46	18.50		425.49	54.91	15.00	84.98		76.25		49.70
159.66	10.50			167.05		52.87		402.45		9.50
711.98	273.38	34.50		1,311.19	314.47	2,311.71		645.59		2.50
421.23			11.34	315.24	14.55	2.95		9.55	181.08	
11,194.59	2,495.94	15,029.30	6,328.70	8,359,69	4,158.14	7,007.82	349.72	11,849.76	550.08	3,518.16

TABLE 6.—*Expenditures from United States appropriations received under*

Station	Amount of appropriation	Classified expenditures						
		Salaries	Labor	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$11,564.99	$656.47	$3.70	$38.70	----------	$868.46	$300.87
Arizona	15,000	10,435.92	1,917.83	33.53	55.20	----------	320.63	366.94
Arkansas	15,000	9,200.00	2,310.81	6.21	68.69	$25.91	966.30	543.25
California	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Colorado	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Connecticut (State)	7,500	7,500.00	----------	----------	----------	----------	----------	----------
Connecticut (Storrs)	7,500	7,500.00	----------	----------	----------	----------	----------	----------
Delaware	15,000	11,488.87	1,478.89	15.18	24.15	----------	1,475.79	179.77
Florida	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Georgia	15,000	11,465.00	1,885.11	20.50	219.52	281.79	286.25	170.58
Hawaii	5,000	1,325.00	3.50	.80	31.02	----------	383.71	20.74
Idaho	15,000	12,562.28	1,098.72	22.93	34.32	----------	396.88	119.90
Illinois	15,000	13,315.00	1,685.00	----------	----------	----------	----------	----------
Indiana	15,000	12,729.98	427.66	9.72	7.97	3.58	457.49	88.19
Iowa	15,000	9,428.32	3,579.63	65.47	----------	146.69	507.85	571.62
Kansas	15,000	10,300.00	3,864.16	15.30	46.03	----------	443.96	9.40
Kentucky	15,000	14,444.87	----------	11.89	----------	21.73	113.12	7.50
Louisiana	15,000	11,713.24	1,114.48	22.46	32.25	3.00	599.06	96.52
Maine	15,000	14,944.48	----------	----------	----------	----------	----------	----------
Maryland	15,000	13,247.21	57.50	15.37	----------	----------	186.00	46.60
Massachusetts	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Michigan	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Minnesota	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Mississippi	15,000	10,532.50	3,561.43	59.09	39.57	75.77	44.69	134.03
Missouri	15,000	1,465.06	5,609.43	127.51	324.31	38.42	1,119.54	508.24
Montana	15,000	9,985.85	1,916.90	83.68	16.08	----------	383.61	428.68
Nebraska	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Nevada	15,000	7,187.50	3,469.99	25.45	19.41	----------	146.29	44.29
New Hampshire	15,000	12,303.52	223.53	19.40	18.09	----------	110.96	58.78
New Jersey	15,000	11,430.00	296.26	22.05	----------	784.00	820.30	130.20
New Mexico	15,000	9,452.20	2,680.04	5.45	189.95	438.74	376.00	416.67
New York (Cornell)	13,500	12,210.00	500.14	24.54	----------	----------	482.67	115.65
New York (State)	1,500	1,500.00	----------	----------	----------	----------	----------	----------
North Carolina	15,000	12,820.00	678.57	5.00	4.84	31.67	627.19	113.12
North Dakota	15,000	15,000.00	----------	----------	----------	----------	----------	----------
Ohio	15,000	8,650.01	6,134.97	----------	----------	----------	----------	71.02
Oklahoma	15,000	9,005.00	1,957.44	10.00	8.08	2.00	1,182.87	427.42
Oregon	15,000	12,621.00	1,302.14	5.05	14.57	117.24	577.63	61.64
Pennsylvania	15,000	14,500.00	350.84	----------	.74	----------	82.19	9.92
Rhode Island	15,000	11,697.77	1,149.51	20.70	10.28	161.52	223.45	54.99
South Carolina	15,000	11,145.71	684.67	232.76	68.20	483.18	615.20	246.02
South Dakota	15,000	7,873.25	5,035.84	22.03	39.20	3.54	495.02	213.72
Tennessee	15,000	12,769.33	621.25	5.95	27.50	126.91	307.95	124.96
Texas	15,000	14,854.14	2.74	----------	----------	1.18	132.94	9.00
Utah	15,000	8,350.08	1,774.43	8.81	92.19	953.29	598.37	265.74
Vermont	15,000	9,335.80	2,752.69	40.61	23.07	74.39	550.40	454.23
Virginia	15,000	13,974.84	970.00	----------	----------	----------	10.00	27.68
Washington	15,000	10,936.26	1,846.88	95.20	----------	----------	609.16	48.04
West Virginia	15,000	12,234.96	982.70	----------	----------	24.98	263.37	153.73
Wisconsin	15,000	11,100.00	3,835.00	----------	----------	----------	----------	----------
Wyoming	15,000	12,409.96	881.50	16.69	85.53	----------	995.66	99.59
Total	725,000	573,509.90	69,298.65	1,073.03	1,539.46	3,799.53	17,760.96	6,739.24

the act of March 16, 1906 (Adams Act), for the year ended June 30, 1931

Classified expenditures—Continued

Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land	Balance
			$570.98	$27.17	$922.70	$45.96				
		$15.00	635.02	27.00	154.69		$865.80	$22.44	$150.00	
$15.05	$673.66	7.48	10.31	77.61	777.37		309.85		7.50	
2.38		15.22	1.20		224.18		94.37			
19.00	359.90	4.50	49.56		121.36		112.43		4.50	
	2.80	13.50	12.00	7.64	3,150.43					$48.86
	50.00		109.29		277.17		323.66	4.85		
17.00	232.43			26.05	892.43	107.50				
	90.11		3.01	43.61	531.12		32.57			
	165.42		33.15		11.50		111.08			
	34.14				284.25	82.50				
5.70	543.67	13.50	97.73	4.25	539.35	36.18	178.61			
							55.52			
			4.55	27.20	1,386.23		29.34			
89.80	6.80	5.00	317.13	2.98	69.87		42.34	4.45	14.55	
65.03	2,919.77		610.66		1,045.85	378.69	44.81		742.68	
	84.73	101.58	257.07	16.46	1,028.49		683.50	5.40	7.97	
	1,856.62	7.27	38.00	617.60	173.25	922.72	491.61			
	451.38		29.46	8.70	1,069.55		107.82		598.81	
3.32	2.40	11.80	8.02	1.10	496.28		343.18	37.67	613.42	
138.34	195.50	4.50	314.48	24.70	67.74	540.00	82.64		73.05	
					167.00					
39.55	105.06		21.76		92.28	22.80	438.16			
	96.00					48.00				
	1,398.01	1.32	150.13	107.98	310.30	285.00	20.00		134.45	
	3.92	18.97	58.07		138.28		57.49	24.00		
			53.16		3.15					
	615.34	115.40	125.12	100.00	94.08	5.00			626.84	
200.00			345.77	18.23	337.42	125.00	371.74	50.60	75.50	
23.83	18.20	26.84	231.59	63.60	413.87		520.22		19.25	
7.05		99.84	14.85	210.69	577.44		71.54		34.74	
			1,824.11	33.70	669.90		379.61		49.77	
35.09	6.06	17.97	154.59	80.45	1,366.56	32.25	56.48		19.36	
			12.78				4.70			
		16.50	20.65	111.72	699.02		616.57			
146.26	133.95		21.14	304.50	516.88		210.95		6.58	
							65.00			
	57.00		97.30		53.38	27.00	276.39			
807.40	10,102.87	496.19	6,232.64	1,942.94	18,663.37	2,658.60	6,997.98	149.41	3,178.97	48.86

TABLE 7.—*Expenditures from United States appropriations received under*

Station	Amount of appropriation	Classified expenditures						
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies
Alabama	$60,000	$39,544.11	$6,597.85	$100.00	$546.18	$375.61	$341.98	$2,292.53
Arizona	60,000	40,817.08	5,740.43	666.26	142.10	536.31	95.17	2,564.82
Arkansas	60,000	42,882.18	2,795.89	6,314.95	431.07	103.14	----------	536.69
California	60,000	56,800.57	3,199.43	----------	----------	----------	----------	----------
Colorado	60,000	48,842.57	2,968.67	1,470.47	530.61	3.38	13.96	755.74
Connecticut (State)	30,000	20,600.00	5,503.77	17.25	139.25	49.14	----------	994.88
Connecticut (Storrs)	30,000	22,097.14	2,003.36	----------	816.12	5.86	----------	----------
Delaware	60,000	40,461.51	5,933.91	1,755.01	234.91	108.84	860.24	775.10
Florida	60,000	42,276.67	7,176.56	1,439.25	142.68	149.99	39.52	1,547.24
Georgia	60,000	34,943.82	8,554.22	1,890.65	258.90	651.34	1,123.86	691.42
Idaho	60,000	40,917.56	4,175.27	873.44	261.02	332.85	310.76	2,389.49
Illinois	60,000	36,225.67	6,791.01	3,257.59	1,087.87	549.64	----------	299.69
Indiana	60,000	41,630.64	4,228.33	450.17	369.06	365.17	44.31	334.09
Iowa	60,000	33,502.10	9,661.53	1,240.22	587.83	45.40	1,024.80	1,086.26
Kansas	60,000	30,000.00	21,209.88	24.54	53.60	180.41	63.95	1,100.48
Kentucky	60,000	49,114.94	3,163.72	1,885.83	145.81	24.89	24.12	697.52
Louisiana	60,000	42,740.77	6,678.55	----------	341.51	381.59	212.24	171.06
Maine	60,000	40,372.47	2,622.89	16.65	155.42	168.19	477.77	544.44
Maryland	60,000	43,090.41	5,038.71	530.85	187.12	8.00	20.72	1,722.17
Massachusetts	60,000	48,255.00	4,215.05	738.22	220.65	59.50	58.54	550.34
Michigan	60,000	42,001.08	7,054.25	2,271.19	307.85	15.46	----------	360.39
Minnesota	60,000	52,638.53	1,542.25	421.87	66.63	37.15	----------	603.35
Mississippi	60,000	37,765.58	7,498.59	1,288.57	323.60	657.50	585.13	494.76
Missouri	60,000	24,559.06	16,479.66	578.38	697.24	558.61	134.14	2,212.31
Montana	60,000	33,909.19	15,577.22	341.81	157.23	140.67	145.46	863.86
Nebraska	60,000	39,154.27	5,700.15	1,898.49	48.30	81.56	190.00	502.07
Nevada	60,000	33,631.74	13,639.43	736.02	617.84	139.90	164.48	1,293.54
New Hampshire	60,000	43,820.47	4,000.99	1,254.93	280.77	151.22	----------	963.17
New Jersey	60,000	42,300.00	6,894.16	10.33	157.70	3.00	205.00	2,195.72
New Mexico	60,000	31,150.18	8,775.77	1,085.09	408.77	1,462.91	493.12	190.65
New York (Cornell)	54,000	46,782.13	612.15	11.50	837.16	.56	----------	87.18
New York (State)	6,000	4,500.00	1,260.00	----------	----------	----------	----------	201.50
North Carolina	60,000	42,578.34	4,393.17	1,074.91	417.79	70.64	105.06	1,234.87
North Dakota	60,000	48,277.50	708.92	3,551.69	559.60	1.28	----------	890.68
Ohio	60,000	38,738.82	12,972.70	374.00	182.41	.13	759.50	1,002.24
Oklahoma	60,000	31,640.00	11,381.81	208.70	499.11	26.14	40.00	474.45
Oregon	60,000	35,282.67	8,312.36	4,368.53	249.23	110.16	236.38	690.90
Pennsylvania	60,000	38,694.45	7,452.46	1,713.06	92.15	294.00	706.76	600.94
Rhode Island	60,000	38,947.71	8,584.62	223.33	407.46	122.47	853.15	278.05
South Carolina	60,000	39,907.77	5,494.26	2,903.64	695.24	171.12	40.97	1,030.81
South Dakota	60,000	35,483.95	8,700.12	2,261.09	391.45	219.22	87.00	728.80
Tennessee	60,000	48,853.25	1,120.56	261.00	114.47	339.90	256.44	1,084.29
Texas	60,000	36,251.63	15,569.07	----------	479.82	216.25	89.27	1,051.64
Utah	60,000	33,542.74	13,682.87	451.87	1,037.37	210.06	27.00	980.15
Vermont	60,000	29,952.01	10,167.49	2,097.05	764.43	307.09	2,191.98	1,031.07
Virginia	60,000	42,568.26	6,171.84	1,793.06	218.16	10.59	28.74	312.56
Washington	60,000	40,307.11	7,602.34	3,001.65	321.41	2.00	42.60	1,076.23
West Virginia	60,000	43,983.59	4,194.72	----------	46.95	17.22	16.10	272.98
Wisconsin	60,000	37,620.00	15,843.73	----------	33.84	----------	----------	1,301.77
Wyoming	60,000	35,587.69	10,909.33	1,074.21	144.10	205.12	58.06	478.80
Total	2,880,000	1,925,544.93	360,556.02	57,927.32	17,209.79	9,671.18	12,168.28	43,543.69

the act of February 24, 1925 (Purnell Act), for the year ended June 30, 1931

Classified expenditures—Continued

Seeds, plants, and sundry supplies	Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land
$705.82	$82.59	$699.34	$466.59	$1,853.57	$1,025.04	$3,484.65	$30.50	$1,428.59	$407.75	$17.30
511.93	372.00	658.32	8.80	1,319.36	399.63	1,057.37	----------	4,271.11	3.00	836.31
341.63	----------	208.89	588.45	154.14	813.11	2,935.52	10.00	1,828.54	34.75	21.05
197.81	----------	301.91	55.60	247.88	55.52	711.32	----------	3,785.21	30.00	29.35
293.95	361.35	----------	----------	476.53	35.34	175.90	----------	1,139.77	134.49	78.38
62.74	----------	----------	138.05	----------	837.63	860.59	----------	3,143.01	----------	35.50
639.73	203.27	2,206.84	276.30	130.41	1,466.76	386.71	----------	3,710.67	51.29	[1] 439.01
898.07	301.93	843.23	14.00	375.35	270.78	552.71	345.25	3,133.14	200.00	239.63
1,200.48	264.32	4,107.55	77.72	760.62	209.62	1,526.72	451.00	2,987.82	38.00	261.94
657.67	----------	423.45	93.28	1,503.32	1,546.01	1,240.49	232.50	4,508.98	25.59	508.32
1,119.94	----------	782.10	.75	1,552.10	1,811.49	2,505.74	----------	4,014.76	1.65	----------
587.73	----------	45.53	----------	508.54	331.55	2,541.94	----------	8,514.94	48.00	----------
2,119.83	91.74	3,532.00	----------	549.09	241.42	3,081.76	595.71	2,478.33	161.98	----------
527.45	----------	662.38	----------	2,981.58	102.17	150.20	1,125.65	1,509.65	28.51	279.55
249.68	1.20	627.65	25.09	11.50	437.25	14.40	9.50	3,566.90	----------	----------
844.78	251.77	2,748.16	----------	1,339.86	15.28	936.11	1,109.45	2,143.52	----------	85.35
1,032.21	179.36	1,653.03	100.03	1,420.47	1,041.65	3,878.58	----------	5,246.67	456.22	633.95
729.30	614.29	294.47	16.78	1,524.21	632.77	1,739.01	120.00	3,681.19	----------	50.00
483.75	----------	43.68	109.34	408.63	184.88	991.07	118.92	3,527.25	4.00	31.18
479.27	----------	152.14	125.17	478.35	347.73	614.11	4.00	5,744.31	44.70	----------
141.42	----------	961.99	8.87	86.58	28.35	1,087.01	87.49	2,276.26	12.25	----------
1,000.63	440.89	3,767.85	101.11	2,560.42	294.99	1,517.46	414.55	1,116.53	21.26	150.58
1,341.99	6.20	4,713.89	70.34	1,282.61	313.29	3,640.62	1,071.61	2,020.45	157.64	161.96
807.51	15.83	124.46	47.17	896.31	162.96	993.08	226.72	5,581.58	2.94	6.00
358.16	29.10	5,688.88	23.27	410.02	694.20	2,574.17	828.53	1,801.07	.51	17.25
775.06	14.35	2,389.67	16.76	881.14	1,053.92	358.52	60.50	3,344.59	85.50	797.04
1,054.19	453.61	204.56	23.40	1,223.64	190.16	2,170.93	35.00	3,136.10	104.98	931.88
595.90	----------	420.82	137.22	649.93	323.74	1,192.81	66.40	4,366.65	82.52	398.70
5,051.11	----------	3,957.53	32.85	1,054.76	954.02	137.52	459.60	4,411.86	9.00	365.26
81.04	----------	56.28	.40	95.48	3,075.93	508.06	21.08	1,831.05	----------	----------
----------	----------	----------	----------	38.50	----------	----------	----------	----------	----------	----------
361.99	445.05	4,752.68	134.04	219.30	484.91	161.96	423.50	2,608.72	433.07	100.00
473.03	46.70	1,588.68	23.13	216.17	196.41	549.62	50.00	2,866.59	----------	----------
1,122.31	----------	3,696.29	10.03	29.33	26.75	916.19	125.00	44.30	----------	----------
1,704.69	19.07	5,440.82	----------	1,878.50	1,008.80	2,396.55	1,441.45	1,638.28	----------	201.63
1,393.08	7.30	430.60	8.50	2,526.19	976.33	701.23	30.00	4,290.96	370.58	15.00
112.24	25.53	927.67	----------	2,885.92	----------	1,045.03	1,097.00	4,203.22	----------	149.57
686.17	449.04	1,035.63	433.32	1,194.84	34.25	480.66	----------	1,391.52	----------	4,877.78
634.19	319.59	1,857.99	15.00	798.92	600.06	868.62	1,540.22	3,121.60	----------	----------
806.01	8.10	1,212.65	124.70	2,091.05	1,798.33	3,154.30	78.95	2,546.33	5.93	302.02
585.41	42.46	----------	223.44	788.01	458.68	3,187.43	14.85	1,586.33	1.08	1,082.40
858.55	108.00	535.21	76.46	514.33	179.80	824.40	----------	1,620.66	945.59	679.38
913.96	----------	18.00	89.96	169.97	734.55	521.73	5.00	7,031.09	----------	583.68
282.56	18.35	676.68	28.37	6,534.91	1,041.92	707.10	----------	2,937.39	374.18	887.42
210.52	----------	504.32	67.14	368.75	189.23	761.01	----------	6,642.89	----------	152.93
938.63	10.75	2.60	123.56	590.47	1,033.16	1,673.86	187.30	2,922.45	----------	163.88
1,318.41	----------	2,734.77	28.45	406.87	252.00	391.61	385.00	1,951.33	----------	4,000.00
754.21	----------	98.60	----------	309.60	504.28	757.69	16.90	2,759.38	----------	----------
1,027.48	----------	3,688.77	153.10	868.57	854.40	421.91	263.15	4,087.46	177.85	----------
39,074.22	5,183.74	71,478.56	4,096.48	49,166.60	29,271.05	63,085.98	13,082.28	154,500.40	4,454.81	19,625.18

[1] Balance, $359.49.

TABLE 8.—*Expenditures from supplementary funds received from sources within the States for the year ended June 30, 1931*

State	Classified expenditures								
	Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies	Fertilizers
Alabama	$101,591.13	$17,218.60	$912.28	$2,418.51	$2,726.86	$5,478.49	$862.82	$8,455.45	$5,941.91
Arizona	47,060.24	15,678.12	3,034.89	1,813.12	484.17	868.06	1,404.10	3,899.87	2,865.72
Arkansas	57,636.35	20,127.12	208.25	2,681.49	563.22	2,908.76	6,381.51	2,257.16	1,362.45
California	395,631.73	178,322.10	23,884.36	18,724.15	7,349.03	21,614.81	21,182.51	42,473.10	8,213.63
Colorado	62,861.22	35,080.49	3,553.80	2,824.44	1,593.55	846.04	5,943.52	6,036.35	278.96
Connecticut (State)	100,102.00	91,232.80	499.48	3,494.79	343.24	6,994.14	2,161.53	6,863.28	1,761.45
Connecticut (Storrs)	22,665.11	18,388.26	42.00	1,608.63	523.37		2,387.15	1,334.70	709.78
Delaware	5,016.21	12,273.32		918.23	265.66	2,625.39		3,590.58	321.33
Florida	194,316.39	66,846.78	15,612.15	8,584.68	3,545.48	12,329.33	10,602.78	14,142.73	7,895.11
Georgia	3,536.96	2,987.99	48.17	517.51	389.07	516.26	18.64	705.38	15.00
Hawaii	5,820.00	12,396.48		76.90	635.09	849.65		4,031.08	314.20
Idaho	20,114.63	6,927.07	962.76	653.91	361.39	650.27	1,273.95	4,931.37	
Illinois	254,660.92	120,724.64	21,372.24	4,927.05			14,238.14	28,647.81	5,660.95
Indiana	250,442.82	113,222.45	9,161.42	40,893.60	3,429.88	12,922.92	38,094.38	7,213.77	7,802.34
Iowa	190,901.30	24,365.68	12,150.39	5,117.16	1,804.33	1,260.59	4,154.51	20,252.90	783.87
Kansas	34,273.79	70,634.46	697.70	6,278.62	2,911.08	6,213.07	2,905.36	6,464.48	
Kentucky	149,779.39	50,179.39	1,117.92	4,174.09	2,473.88	6,688.22	3,305.81	17,882.57	1,344.73
Louisiana	77,629.02	34,816.13	442.50	2,042.14	1,591.43	2,196.83	1,836.40	4,684.68	2,746.70
Maine	18,721.94	15,296.22	144.29	1,080.00	545.65	2,585.15	461.74	2,783.25	1,644.17
Maryland	50,240.12	32,178.65	4,304.31	1,578.58	1,987.21	2,764.26	2,251.76	5,463.44	1,927.94
Massachusetts	96,847.65	47,629.45	3,182.18	2,094.62	1,803.31	1,785.53	7,450.69	5,199.72	888.35
Michigan	159,245.34	95,334.08	15,655.61	3,962.08	1,677.41	1,519.97	6,553.11	18,775.82	2,164.51
Minnesota		250,297.84	18,201.36	6,229.21	2,099.92	18,908.63	11,715.65	15,824.71	658.83
Mississippi	4,507.92	2,397.94		30.87	165.78	581.61	29.44	310.21	550.96
Missouri	51,031.80	28,613.99	9,415.86	4,138.22	1,784.32	1,658.06	6,738.36	5,934.14	53.45
Montana	65,755.58	25,408.26	4,335.36	2,558.95	433.99	4,092.12	1,551.36	10,905.58	162.05
Nebraska	90,311.73	29,582.04	4,688.40	2,037.85	1,603.20	6,909.38	5,476.75	2,593.67	7,546.26
Nevada	2,229.50		12.06	152.29	16.52	2,593.71	89.34	495.79	
New Hampshire	21,547.86	6,389.08	698.14	421.75	879.33	7.50	1,674.91	6,687.97	349.06
New Jersey	359,382.10	20,884.90	22,079.10	12,818.45	4,243.89	11,792.88	15,026.23	6,073.06	2,669.15
New Mexico	10,634.73	9,135.51	213.57	321.44	411.68	870.93	392.25	1,108.22	29.98
New York (Cornell)	323,220.92	50,917.00	16,445.04	8,492.65	1,726.39	22,919.36	12,813.39	22,526.94	
New York (State)	166,450.00	33,999.50	7,901.26	4,600.88	906.24	9,750.00	6,147.45	1,877.63	143.30
North Carolina	40,284.76	8,895.03	472.84	1,749.01	237.35	1,247.65	1,448.87	1,753.69	1,743.77
North Dakota	77,365.24	28,479.10	5,155.23	2,035.23	3,049.38	17,591.13	16,955.73	9,804.25	22.94
Ohio	327,055.88	180,798.76	37,734.04	7,765.78	5,920.68	28,588.71	7,258.55	41,069.07	3,482.46
Oklahoma	84,755.12	18,460.18	1,754.18	2,337.71	1,080.69	833.29	4,523.46	1,241.97	

Oregon	124,016.59	31,485.57	3,338.64	3,906.71	1,017.76	4,962.52	6,320.42	5,117.64	403.95
Pennsylvania	78,049.47	33,524.03	2,533.78	3,451.63	1,472.44	2,192.69	4,248.68	8,522.54	1,648.83
Rhode Island	1,294.54	2,313.87	98.55	91.00	166.92	92.21	11.97	229.64	19.00
South Carolina	35,249.40	34,690.63	1,011.06	1,178.44	735.42	879.62	3,576.03	8,664.51	4,249.23
South Dakota	18,627.02	9,493.02	1,163.57	336.38	447.95	317.77	198.45	1,310.61	138.66
Tennessee	24,735.73	11,607.73	330.13	716.85	840.69	2,276.15	89.56	2,559.32	470.92
Texas	231,697.82	88,632.59	10,047.42	8,384.38	2,952.72	11,084.07	5,459.42	21,640.70	1,367.27
Utah	33,879.46	24,691.65	3,611.56	2,177.86	469.44	10,637.01	1,727.53	3,581.45	58.00
Vermont	6,023.75	3,063.41	2,486.10	446.98	63.14	689.25	223.72	46.21	39.00
Virginia	57,502.96	13,092.54	2,213.01	1,084.43	626.07	1,257.46	793.50	2,153.24	2,442.11
Washington	49,152.33	42,712.52	2,902.70	951.21	6,979.89	32.91	1,335.82	10,291.36	281.22
West Virginia	40,379.50	34,685.41	3,059.15	1,261.54	2,301.08	3,086.36	617.79	15,497.55	515.98
Wisconsin	184,295.79	85,451.71	11,018.77	8,095.42	3,148.22	9,894.41	9,894.41	19,778.82	3,597.97
Wyoming	40,158.04	7,086.71	291.90	415.80	765.72	755.90	----------	10,131.89	----------
Total	4,848,689.80	2,198,650.80	290,199.48	204,653.22	83,551.13	270,121.03	259,809.45	453,821.87	87,287.45

TABLE 8.—*Expenditures from supplementary funds received from sources within the States for the year ended June 30, 1931*—Continued

State	Classified expenditures—Continued										
	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land	Balance	Total
Alabama	$7,893.78	$531.86	$11,698.44	$2,038.17	$747.28	$1,155.78	$8,584.64	$3,609.13	$31,389.39	$45,858.63	$259,113.15
Arizona	1,585.17		2,180.47	2,618.52		5,852.68	6,191.31	1,095.79	13,411.46		110,043.69
Arkansas	4,576.97	255.16	6,449.56	1,569.77	8,278.67	777.81	2,677.51	6,899.33	12,922.57		138,533.66
California	55,220.84	4,322.06	27,883.10	7,349.02	9,942.81	19,891.62	39,122.80	13,185.03	73,490.35	112,937.37	1,080,740.42
Colorado	10,895.17	826.79	3,455.78	1,597.51	4,303.90	3,859.58	10,314.82	416.91	7,640.32	11,042.96	173,372.11
Connecticut (State)	591.01	2,027.41	10,152.24	2,205.99	2,150.58		11,422.46	2,687.82	5,411.88	763.09	250,865.19
Connecticut (Storrs)	4,598.95	924.11	162.51	623.46	2,823.03	2,054.93	2,747.51	1,344.65	1,205.47	1,051.44	65,195.06
Delaware	6,021.59	139.62	1,999.88	687.20			330.20	6.00	3,573.46	3,331.65	41,100.32
Florida	10,137.05	5,374.90	20,104.37	12,783.43	6,592.65	2,427.38	18,366.04	2,744.89	58,923.76	26,217.76	497,547.66
Georgia	642.47	218.68	601.88	170.86	306.81	159.50	1,529.07	15,293.69	3,460.17	7,001.73	38,119.84
Hawaii	7,824.65		3,206.84				310.18	68.80	4,595.00		40,128.87
Idaho	4,072.78	41.73	2,844.80	316.04	2,520.68	180.00	3,861.87	2,029.90	1,626.46		53,369.61
Illinois	37,225.00	1,234.81	7,859.68	2,077.62	2,822.43	5,605.66	14,238.27		9,760.60		531,055.82
Indiana	30,628.32	2,462.18	12,765.49	4,970.91	8,524.48	2,978.50	26,390.74	3,705.94	34,153.59	149,423.16	759,186.89
Iowa	12,372.06	18.10	755.29	656.17	5,531.82	738.62	12,602.51	40.67	333.03	9,023.93	302,862.93
Kansas	9,931.51	303.56	12,416.98	2,431.75	981.47	1,897.85	5,024.02	1,807.71	21,860.34	10,339.75	197,373.50
Kentucky	16,480.26	2,013.23	2,400.45	2,109.06	1,337.96	3,369.73	14,657.81	7,563.52	69,396.10	44,163.58	400,437.70
Louisiana	3,807.61	55.72	7,492.43	724.34	360.33	2,597.08	8,693.52	1,433.02	12,483.76	21,495.28	187,128.92
Maine	3,895.94	425.42	3,649.80	906.25	1,384.40		1,108.64	686.16	35,937.70		91,256.72
Maryland	12,600.47	491.34	2,820.35	105.88	1,305.66	1,508.15	1,684.55	2,728.65	2,450.22		128,391.54
Massachusetts	2,221.28	361.51	3,533.59	2,321.53	5,092.61		9,724.73		8,787.01	93,359.12	292,282.88
Michigan	16,687.53	1,453.30	11,316.15	2,112.92	5,121.43	4,142.65	19,367.40	3,113.35	3,845.74		372,048.40
Minnesota	19,568.72	2,475.82	11,812.23	1,571.76	747.83	6,151.20	14,865.02	3,278.55	20,913.90		405,321.18
Mississippi	1,344.00	15.00	1,486.91	86.80		1,662.50	380.21	771.60	124.04	7,774.71	22,220.50
Missouri	7,875.53	382.59	3,309.38	988.32	3,479.81	7,517.39	4,469.58	536.53	6,335.33	31,799.32	176,061.98
Montana	15,205.64	426.68	2,910.10	1,563.89	133.74	2,098.93	4,756.55	15.00	5,764.62	161.58	148,239.98
Nebraska	32,522.80	189.26	6,687.57	1,166.53	5,898.31	18,690.11	3,746.28	1,504.48	19,714.81		240,869.43
Nevada	150.82	378.84	78.65		30.70	7.25	970.28	661.10	435.59	361.84	8,664.28
New Hampshire	495.35	141.33	445.26	180.85	752.56	20.40	4,487.68	514.76	204.42	9,871.24	55,769.45
New Jersey	43,312.03	2,586.29	7,207.67	2,319.34	26,117.55	17,435.60	22,799.23	13,309.60	35,934.86	1,796.26	627,788.19
New Mexico	2,824.12	225.73	1,200.73	584.67	107.75	227.25	701.94	633.80	1,434.97	30,261.93	61,321.20
New York (Cornell)	16,418.97	2,774.56	10,766.47	18,877.21	119,005.49	843.51	31,013.17	2,433.72	178,955.12		840,149.91
New York (State)	4,599.18	2,541.40	12,548.71	621.70	435.66	75.00	4,999.99	729.40	16,780.36	4,781.43	279,889.09
North Carolina	5,086.60	461.72	1,655.66	854.32	164.13	663.35	9,732.81	96.56	2,181.44	5.82	78,735.38
North Dakota	24,646.52	622.62	5,334.41	1,237.51	946.15	6,872.82	3,805.41	4,361.86	9,489.83	3,730.93	221,506.29
Ohio	40,362.41	1,704.27	9,124.16	2,415.81	3,565.08	9,779.60	19,825.65	6,921.36	100,004.44	218,536.77	1,051,913.48
Oklahoma	9,048.91	1,283.03	1,640.23	1,016.88	1,423.26	3,890.93	10,655.93	4,356.23	27,156.27	17,687.49	193,145.76
Oregon	8,853.28		6,116.39	1,989.14	274.69	625.00	9,866.22	13,726.50	3,500.93	67,521.59	293,043.54
Pennsylvania	11,150.14	438.34	2,828.14	744.73	1,007.72	2,016.56	7,850.51			1,799.06	163,479.29

Rhode Island	169.97	12.71	386.31	46.15								
South Carolina	18,612.48		3,504.77	190.13	5,121.54	2,555.81	4,664.37	21.80	3,513.55		128,408.79	
South Dakota	7,701.03	60.00	1,161.91	137.17	205.56	3,457.40	1,931.19	63.53	898.51	9,046.81	56,696.54	
Tennessee	6,631.04	94.37	2,486.02	888.76	43.09	4,799.63	2,066.88	1,029.88	3,710.76	1,126.00	66,503.45	
Texas	16,878.39	1,862.12	18,416.88	2,940.84	3,663.36	4,617.85	30,196.05	21,957.92	23,294.51	79,568.73	589,663.04	
Utah	1,806.92	394.63	2,549.16	1,970.81	1,389.61	826.55	6,014.82	394.24	5,716.33		101,697.03	
Vermont	5,863.62	136.75	83.20	206.85	3.25		2,102.37	322.11	122.74	215.41	22,197.86	
Virginia	6,577.06	339.58	2,497.40	396.59	1,907.09	6,924.40	7,504.72	134.30	5,273.67	15,319.15	128,039.28	
Washington	10,480.57	2,752.60	2,222.37	876.97	1,215.46	367.00	4,451.18		8,706.01	5,575.07	151,277.19	
West Virginia	12,130.56	16.50	861.39	1,279.04	125.38	5,104.94	2,396.52	2,561.40	15,188.14	457.42	141,525.65	
Wisconsin	25,625.51	2,248.73	12,592.02	3,148.22	4,497.46	8,990.92	17,889.83	5,396.95	34,180.68		449,745.84	
Wyoming	8,930.12			3,486.79		2,760.42	1,695.84	1,386.34	9,927.88	9,838.95	97,632.30	
Total	624,782.70	48,046.96	287,664.18	102,164.18	252,391.23	178,169.84	455,142.29	157,633.08	962,534.86	1,053,443.78	12,818,757.33	

TABLE 9.—*Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved March 2, 1887, March 16, 1906, February 24, 1925, and May 16, 1928*

State or Territory	Hatch Act		Adams Act		Purnell Act	
	1888–1930	1931	1906–1930	1931	1926–1930	1931
Alabama	$643,956.42	$15,000.00	$341,619.89	$15,000.00	$200,000.00	$60,000.00
Arizona	609,803.10	15,000.00	344,955.61	15,000.00	200,000.00	60,000.00
Arkansas	643,139.12	15,000.00	344,900.00	15,000.00	200,000.00	60,000.00
California	645,000.00	15,000.00	344,926.84	15,000.00	200,000.00	60,000.00
Colorado	644,718.82	15,000.00	343,638.93	15,000.00	200,000.00	60,000.00
Connecticut	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Dakota Territory	56,250.00					
Delaware	643,382.87	15,000.00	340,475.12	15,000.00	199,295.10	60,000.00
Florida	644,966.04	15,000.00	344,993.06	15,000.00	196,523.74	60,000.00
Georgia	640,593.43	15,000.00	332,092.87	15,000.00	200,000.00	60,000.00
Hawaii	15,000.00	15,000.00		5,000.00		
Idaho	569,324.13	15,000.00	340,842.22	15,000.00	200,000.00	60,000.00
Illinois	644,554.95	15,000.00	344,851.62	15,000.00	200,000.00	60,000.00
Indiana	644,901.19	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Iowa	645,000.00	15,000.00	345,000.00	15,000.00	197,965.17	60,000.00
Kansas	644,995.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Kentucky	644,995.57	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Louisiana	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Maine	644,999.62	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Maryland	644,967.40	15,000.00	344,236.48	15,000.00	200,000.00	60,000.00
Massachusetts	644,617.70	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Michigan	644,676.10	15,000.00	341,341.20	15,000.00	200,000.00	60,000.00
Minnesota	644,917.78	15,000.00	344,345.00	15,000.00	200,000.00	60,000.00
Mississippi	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Missouri	640,097.24	15,000.00	344,999.90	15,000.00	200,000.00	60,000.00
Montana	555,000.00	15,000.00	342,417.04	15,000.00	200,000.00	60,000.00
Nebraska	644,932.16	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Nevada	644,214.32	15,000.00	343,180.28	15,000.00	200,000.00	60,000.00
New Hampshire	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
New Jersey	644,949.97	15,000.00	344,392.06	15,000.00	200,000.00	60,000.00
New Mexico	609,509.05	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
New York	644,757.18	15,000.00	344,463.01	15,000.00	200,000.00	60,000.00
North Carolina	645,000.00	15,000.00	330,000.00	15,000.00	200,000.00	60,000.00
North Dakota	586,502.26	15,000.00	344,638.85	15,000.00	200,000.00	60,000.00
Ohio	645,000.00	15,000.00	343,514.02	15,000.00	200,000.00	60,000.00
Oklahoma	569,002.16	15,000.00	324,535.19	15,000.00	200,000.00	60,000.00
Oregon	630,156.64	15,000.00	340,000.00	15,000.00	200,000.00	60,000.00
Pennsylvania	644,957.43	15,000.00	344,995.41	15,000.00	200,000.00	60,000.00
Rhode Island	645,000.00	15,000.00	339,520.20	15,000.00	200,000.00	60,000.00
South Carolina	644,542.15	15,000.00	343,460.12	15,000.00	200,000.00	60,000.00
South Dakota	588,250.00	15,000.00	340,000.00	15,000.00	200,000.00	60,000.00
Tennessee	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Texas	645,000.00	15,000.00	342,592.26	15,000.00	200,000.00	60,000.00
Utah	510,000.00	15,000.00	344,821.94	15,000.00	200,000.00	60,000.00
Vermont	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Virginia	642,824.12	15,000.00	344,949.01	15,000.00	200,000.00	60,000.00
Washington	582,102.65	15,000.00	341,080.11	15,000.00	200,000.00	60,000.00
West Virginia	644,968.71	15,000.00	342,859.12	15,000.00	200,000.00	60,000.00
Wisconsin	645,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Wyoming	630,000.00	15,000.00	345,000.00	15,000.00	200,000.00	60,000.00
Total	30,356,546.28	735,000.00	16,459,640.36	725,000.00	9,593,784.01	2,880,000.00

ADDRESS LIST OF STATE AND INSULAR AGRICULTURAL EXPERIMENT STATIONS

ALABAMA.—*Auburn,* M. J. Funchess, Director.
ALASKA.—*Juneau,* H. W. Alberts, Director.
ARIZONA.—*Tucson,* P. S. Burgess, Director.
ARKANSAS.—*Fayetteville,* Dan T. Gray, Director.
CALIFORNIA.—*Berkeley,* C. B. Hutchison, Director.
COLORADO.—*Fort Collins,* C. P. Gillette, Director.
CONNECTICUT.—*New Haven,* W. L. Slate, Director; *Storrs,* W. L. Slate, Director.
DELAWARE.—*Newark,* C. A. McCue, Director.
FLORIDA.—*Gainesville,* Wilmon Newell, Director.
GEORGIA.—*Experiment,* H. P. Stuckey, Director.
GUAM.—*Guam,* C. W. Edwards, Director.
HAWAII.—*Honolulu,* J. M. Westgate, Director.
IDAHO.—*Moscow,* E. J. Iddings, Director.
ILLINOIS.—*Urbana,* H. W. Mumford, Director.
INDIANA.—*La Fayette,* J. H. Skinner, Director.
IOWA.—*Ames,* C. F. Curtiss, Acting Director.
KANSAS.—*Manhattan,* L. E. Call, Director.
KENTUCKY.—*Lexington,* T. P. Cooper, Director.
LOUISIANA.—*Baton Rouge,* C. T. Dowell, Director.
MAINE.—*Orono,* F. Griffee, Director.
MARYLAND.—*College Park,* H. J. Patterson, Director.
MASSACHUSETTS.—*Amherst,* F. J. Sievers, Director.
MICHIGAN.—*East Lansing,* V. R. Gardner, Director.
MINNESOTA.—*University Farm, St. Paul,* W. C. Coffey, Director.
MISSISSIPPI.—*State College,* W. R. Perkins, Director.
MISSOURI.—*Columbia,* F. B. Mumford, Director.
MONTANA.—*Bozeman,* F. B. Linfield, Director.
NEBRASKA.—*Lincoln,* W. W. Burr, Director.
NEVADA.—*Reno,* S. B. Doten, Director.
NEW HAMPSHIRE.—*Durham,* J. C. Kendall, Director.
NEW JERSEY.—*New Brunswick,* J. G. Lipman, Director.
NEW MEXICO.—*State College,* Fabian Garcia, Director.
NEW YORK.—*Geneva* (State Station), U. P. Hedrick, Director; *Ithaca* (Cornell Station), C. Betten, Acting Director.
NORTH CAROLINA.—*State College Station, Raleigh,* R. Y. Winters, Director.
NORTH DAKOTA.—*State College Station, Fargo,* P. F. Trowbridge, Director.
OHIO.—*Wooster,* C. G. Williams, Director.
OKLAHOMA.—*Stillwater,* C. P. Blackwell, Director.
OREGON.—*Corvallis,* W. A. Schoenfeld, Director.
PENNSYLVANIA.—*State College,* R. L. Watts, Director.
PUERTO RICO.—*Mayaguez,* T. B. McClelland, Director.
RHODE ISLAND.—*Kingston,* B. E. Gilbert, Director.
SOUTH CAROLINA.—*Clemson College,* H. W. Barre, Director.
SOUTH DAKOTA.—*Brookings,* J. W. Wilson, Director.
TENNESSEE.—*Knoxville,* C. A. Mooers, Director.
TEXAS.—*College Station,* A. B. Conner, Director.
UTAH.—*Logan,* P. V. Cardon, Director.
VERMONT.—*Burlington,* J. L. Hills, Director.
VIRGINIA.—*Blacksburg,* A. W. Drinkard, jr., Director.
VIRGIN ISLANDS, U. S. A.—*Christiansted, St. Croix,* Glen Briggs, Acting Director.
WASHINGTON.—*Pullman,* E. C. Johnson, Director.
WEST VIRGINIA.—*Morgantown,* F. D. Fromme, Director.
WISCONSIN.—*Madison,* C. L. Christensen, Director.
WYOMING.—*Laramie,* J. A. Hill, Director.